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U. S. S. FLORIDA FIRING A BROADSIDE.

Navy Ordnance Activities

World War 1917-1918

WASHINGTON
GOVERNMENT PRINTING OFFICE
1920

NAVY DEPARTMENT,

Washington, January 25, 1920.

MY DEAR ADMIRAL: The Bureau of Ordnance, under your direction, played a very important part in the Navy's successful work during the World War, and therefore it is desirable that this work of the bureau should be recorded at greater length and in more detail than can be done in your annual report.

Such a narration of the work of the bureau will be of value to the Navy and of great interest to all those engaged in the production of ordnance material, civilian as well as naval, and will serve as a record to which reference can be made with advantage should the country unfortunately ever be faced with a similar emergency.

Very sincerely yours,

JOSEPHUS DANIELS,

Secretary of the Navy.

Rear Admiral RALPH EARLE, U. S. Navy,

Chief of Bureau of Ordnance,

Navy Department, Washington, D. C.

NAVY DEPARTMENT, BUREAU OF ORDNANCE,
Washington, D. C., May 1, 1920.

MY DEAR MR. SECRETARY: In accordance with the directions contained in your note of October 1, the bureau has prepared this record of its activities and trusts that all who are interested in the Navy will find pleasure in reading this authoritative statement of the ordnance portion of the Navy's work in the World War.

The preparation of this record was accomplished with the assistance of the present chiefs of the divisions and sections of the bureau as follows:

Assistants to the bureau	Captains T. A. Kearney and C. C. Bloch, U. S. Navy.
Chief clerk	Mr. E. S. Brandt.
Guns	Commander A. C. Pickens.
Turrets	Commander Herbert F. Leary.
Gun mounts	Commander F. L. Reichmuth.
Torpedoes	Commander G. B. Wright.
Industrial	Commander A. L. Norton.
Mines and nets	Lieut. Commander J. B. Glennon.
Fire control	Commander W. R. Furlong.
Aviation	Commander A. C. Stott.
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Experimental	Lieut. Commander O. M. Hustvedt.
Explosives	Commander W. W. Bradley, jr.
Design	Lieut. Commander G. L. Smith.
Supplies	Lieut. Commander T. C. Kinkaid.
Financial	Mr. W. W. Werntz.
Cost board and contracts	Commander John H. Moore.
Buildings and grounds	Lieut. Commander W. W. Little, R. F.
Patents	Mr. P. A. Blair.
Requisitions	Mr. F. B. Blackburn.
Special board on naval ordnance	Rear Admiral N. E. Mason; and
Contracts and merchant ship protection	Rear Admiral A. R. Couden.

the main editing and compilation being the handiwork of the Chief of Bureau; Lieut. Commander T. C. Kinkaid, U. S. Navy; Lieut. Commander T. S. Wilkinson, jr., U. S. Navy; and Chief Gunner R. E. Cox, U. S. Navy.

Very respectfully,

RALPH EARLE,
Chief of Bureau.

The honorable JOSEPHUS DANIELS,
Secretary of the Navy.

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Admiral Benson. | or General Barnett.

INTRODUCTION.

The preparation of this record of the Navy's ordnance during the war had its inception in the desire fittingly to recognize, record, and set forth the services rendered the Navy and the bureau, not alone by line officers of the Navy, deprived of an opportunity to secure war service afloat, because work of the shore establishments had to continue and at a higher rate of pressure than ever before, but also by the reserve officers, the technicists enrolled in class 4; to the end that all these might retain in after years this plain story of duty well done, and that they might feel, in a measure, the bureau's appreciation of the assistance they so splendidly rendered Navy ordnance during the days of hostilities.

The following pages also relate in some degree what has been accomplished, and how the duties of this bureau, charged by law with the design, acquisition, production, and issue of the fighting weapons of the Navy, were performed during the war with the Imperial Governments of Germany and Austria, from April 6, 1917, to November 11, 1918, a period of 19 months.

The officers of this bureau, to whose lot it fell to perform work ashore in this country, strove hard to be worthy of the trust and responsibility placed upon them by their fellow officers, who were under the heavy strain at sea of destroyer, convoy, patrol, mine-laying, mine-sweeping, submarine, aviation, and battleship duty; by day and night, in fair and foul weather, exposed to the dangers of the sea and the enemy's attack, throughout warfare of a type previously unknown and undreamed of in civilized times. We hope that these men believe our work was well done; we must be satisfied, even though we should have felt favored indeed had it been our lot similarly to share the hardships and hazards of duty at sea.

The bureau feels that, to all those who read intensively the history of the World War, there must come the conviction that, after all, naval power was the *ultima ratio* of this titanic war. So let us all, officers, naval and civilian personnel of this great Navy, continue to work for the constant improvement and betterment of the naval profession upon, beneath, and above the seas.

RALPH EARLE,
Chief of Bureau of Ordnance.

MAY 1, 1920.

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FOREWORD.

THE BUREAU'S MISSION.

Before entering into any description of the activities of the Bureau of Ordnance in the duration of the war, a brief statement of the origin of the bureau and of its purposes and functions may be advisable.

In the early organization of the Navy Department, the Bureau of Ordnance was created to assume, under the Secretary of the Navy, a share in the administration of the Navy Department, and in the building and upkeep of the United States Navy. This share is ordnance. To the layman "ordnance" means only guns and ammunition; to the seagoing naval officer it means guns, ammunition, armor, fire control, sights, torpedoes, and mines. Both the layman and the naval officer see the finished product, but many have little idea of the organization and effort that produce these guns, powder, shell, and torpedoes from the initial design to the finished product.

Navy Regulations setting forth the duties of the Bureau of Ordnance, state in one paragraph:

> The duties of the Bureau of Ordnance shall comprise all that relates to the upkeep, repair, and operation of the torpedo stations, naval proving ground, and magazines on shore, to the manufacture of offensive and defensive arms and apparatus (including torpedoes and armor), all ammunition and war explosives. It shall require for or manufacture all machinery, apparatus, equipment, material, and supplies required by or for use with the above.

The most essential part of this is: "All that relates to * * * the manufacture of offensive and defensive arms and apparatus (including torpedoes and armor), of ammunition and war explosives." In other words, the Bureau of Ordnance has the vast responsibility of furnishing our vessels, from dreadnaught to submarine patrol boat, with the weapons with which they are to combat the enemy and uphold the honor of the nation.

The naval forces of a nation at war consist of the vessels actually in the Navy at the outbreak of war, forming what might be called a peace-time Navy; and of the vessels added to the Navy to complete its war-time strength.

The peace-time Navy is built up for years, of vessels designed for fighting purposes only. It must, of course, be prepared for war. When war comes, however, it must be thoroughly scrutinized to make sure that it is ready for war.

The additional vessels added to the Navy in time of war are those pressed into service from their normal mercantile pursuits or those constructed to meet the developing needs of the war. Both these types of vessels are not, like the peace-time fleet, ready for war, but must be thoroughly prepared for their fighting duties.

The Bureau of Ordnance must supply the weapons for the existing fleet, and more for the new war fleet. When war breaks out, the weapons of the peace-time fleet must not be found wanting, and arms and ammunition must be procured for the new fleet.

The war found the ordnance equipment of our existing fleet in excellent condition. As far as standard types of ordnance go, the bureau's problem was to furnish such types in sufficient quantity to arm the new Navy. But the conditions of warfare, changing rapidly from month to month in the great conflict, demanded new weapons to meet new problems and these new weapons had to be devised and supplied not only to the new fleet, but also to the vessels of the regular peace-strength Navy.

The chapters which follow show the scope of the bureau's activities during the war, activities which in the last century would have been inconceivable, but which, in the vast marshaling of the nation's industrial forces, flowed naturally from the duties of the bureau as laid down in that short paragraph in the Navy regulations.

The position of the bureau previous to February 1, 1917, and its work from that date, the declaration of unrestricted submarine warfare, to the actual entrance of the United States into the war, are shown in Chapter I, "The pre-war period." Its organization and initial acts in the war are shown, at the risk of subsequent repetition, in Chapter II. Later chapters take up the several classes of weapons individually, so that a less interrupted and more clearly defined view of the bureau's operations may be obtained than would be found in a simple, chronological record.

The production and issue of previously known weapons are seen in chapters on arming vessels, guns and mounts, ammunition, fire control and optical, torpedoes; the production of new weapons, in depth charges, aviation ordnance, and inventions and research. The problems met with in the production of the vast quantity of munitions are seen in inspection and ordnance plants, and, in detail, in the chapters above noted relating to the materials themselves.

These chapters cover the normal functions of the bureau as an agency supplying the fleet with its weapons. Two great accom-

Koester. Aid to the Secretary of the Navy, H. G. Sparrow.
Bureau of Yards and Docks C. W. Parks
Surgeon General W. C. Braisted.
rdnance R. Earle. Chief of the Bureau of Navigation L. C. Palmer.

plishments of the Navy in the war were initiated by the bureau and the material provided therefor. These are described in the chapters on "The Northern Barrage"—the lines of mines flung for 230 miles across the North Sea—and "The Naval Railway Batteries"—the most powerful guns found on the whole Allied land front.

The mission or purpose of the bureau in the war was to supply every weapon needed by the Navy. How well the bureau fulfilled its mission rests with the Navy at large to judge.

NAVY ORDNANCE ACTIVITIES, WORLD WAR, 1917–1918.

CHAPTER I.

THE PREWAR PERIOD.

In the spring of 1917 world events were throwing the United States daily closer into the European struggle that had started, on July 28, 1914, with the declaration of war on Serbia by Austria, and were indicating that our eventual entrance into this war was by no means an improbability.

The German Government since May 4, 1916, the date of its pledge to President Wilson to adhere to the laws of warfare at sea, had continued to do as it willed; and, among others, the British steamship *Marina* had been sunk by a German submarine in violation of that, known as the *Sussex*, pledge; then the *Lanao*, and next the *Chemung* on November 27, this latter presumably by an Austrian vessel; and so the German Government indicated that submarine warfare was certain to be extended.

On December 7, 1916, Mr. Lloyd-George became premier of Great Britain; the Asquith ministry going out of power.

On January 22, 1917, our President conveyed to the Senate the outcome of his note of December 18 to the belligerents, and gave his views on our foreign policy, suggesting the right of "every great people * * * to a direct outlet to the great highways of the seas."

On January 31, in a note to the United States discussing the message of January 22, the German Government announced its intention of abandoning all legal restrictions on naval warfare in certain designated sea areas.

Then, on February 1, 1917, Germany announced the establishment of her barred zone and laid down certain rules which, if followed by American merchantmen, exempted them from attack; but these rules required a guarantee by our Government that no contraband was carried, and in that case permitted an American passenger vessel to enter Falmouth once a week. It need not be asserted here that such rules were intolerable to our Nation.

On February 3, 1917, in an address to Congress, President Wilson reviewed the German acts, and his protest on April 18, 1916, made after the sinking of the *Sussex*, wherein he declared that "unless the Imperial Government should now, immediately, declare and effect an abandonment of its present methods of warfare against passenger and freight carrying vessels, the Government of the United States can have no choice but to sever diplomatic relations with the German Empire altogether"; and the President announced that "all diplomatic relations between the United States and the German Empire are severed * * * and, in case certain events happen, * * * shall take liberty of coming again before Congress to ask that authority be given me to use any means that may be necessary for the protection of our seamen and our people in the prosecution of their peaceful and legitimate errands on the high seas."

During these stirring world events, the bureau was doing all possible to make ready for the war that seemed inevitable, in accordance with the traditions of a service and a bureau that has always endeavored to be prepared, far-sighted, adventuresome, and forward-looking.

Owing to his foresight and energetic representation to Congress, of the necessity for such provision, Rear Admiral Joseph Strauss, U. S. Navy, then Chief of Bureau of Ordnance, secured in the naval appropriation act of August 29, 1916, allotments of moneys under new titles for "batteries for merchant auxiliaries" not to exceed $3,300,000; for "reserve ordnance supplies," $4,503,524; and for "ammunition for ships of the Navy," $13,720,000. The foregoing provisions of this bill were the first real preparedness measures permitted to this bureau by Congress and enabled it promptly to initiate the action which gave the Bureau of Ordnance its running start in the production of munitions for the great war of 1917. This fact is worthy of special note and emphasizes that the bureau's officers, in the opening days of 1917, were ever mindful and thankful for the far-sighted action of its then chief, as well as to their predecessors in the summer of the year 1916.

Reference has been made to the appropriation of $13,720,000 carried by the act of August 29, 1916, under the heading "Ammunition for ships of the Navy," as being the backbone of the "war reserve" of the naval ammunition supply during the early stages of the war. This amount had previously been determined as sufficient to complete the allotted "war reserve" for all Navy guns then available. The same act, however, established the policy of making appropriations for the ammunition allowance and "war reserve" of new vessels coincident with the appropriations for their construction. The wisdom of this policy is apparent, as otherwise all

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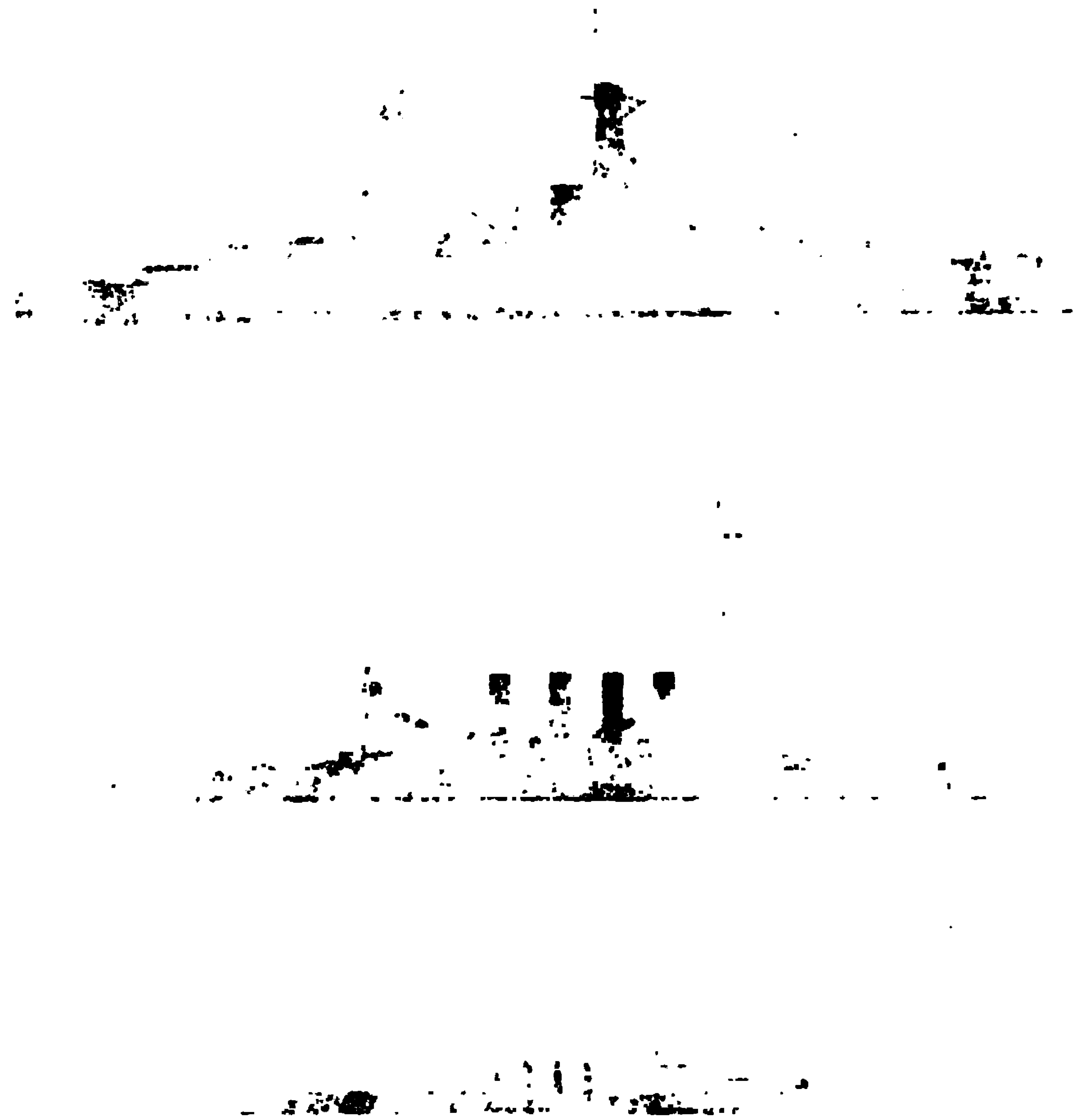


the required ammunition could not be made available by the time the ship was ready for commission, a handicap under which the bureau had long struggled. It is worthy of special note, that subsequent events proved that the establishment of this policy, at this time, was particularly fortunate. The act of August 29, 1916, carried under the heading "Increase of the Navy, ammunition," an appropriation of $19,485,500 toward the ammunition supply for the new vessels therein authorized. Anticipating the passage of this act carrying these large appropriations for ammunition—a total of $33.205,500 under the two headings—the bureau, under date of July 10, 1916, advertised for a total of 943,429 projectiles of all calibers, bids for which were to be opened on the 23d of August following. The contracts placed, as a result of these bids, were the basis of an unfailing and ample supply of projectiles of the 3-inch, 4-inch, and 5-inch calibers, those most used, and the same manufacturers who then began production continued at full capacity until stopped on account of the signing of the armistice in November, 1918.

Again, special appropriations were made in the act approved March 4, 1917, by an allotment under "Ammunition for merchant auxiliaries" of $7,731,941, and a provision of "Antiaircraft guns and ammunition at naval stations" of $3,800,000. The certainty of eventual war was daily becoming more evident, the arming of our merchantmen had begun, and work was entered upon with energy under all these authorizations.

As one of its preparedness measures, in accordance with naval policy, the bureau had assembled guns and mounts of intermediate calibers into reserve batteries, and either placed them in the hands of the naval militia, in store at navy yards, or at the yards assigned to certain vessels, ready for mounting thereon when mobilization orders were issued.

January, 1917, then, found the bureau manufacturing some 134 3-inch antiaircraft, 113 4-inch 50-caliber, and 46 5-inch 51 caliber guns and mounts, all under that wise provision of law for "Batteries for merchant auxiliaries." In addition, the reserve batteries comprised some 30 6-inch, 68 5-inch. 131 4-inch, 84 3-inch, 6 4.7-inch, 96 6-pounder, and 218 3-pounder guns.

The assignment of guns to vessels was by name and comprised batteries for many different types of auxiliaries, such as, *St. Louis*, a liner to be a fleet scout; *Morro Castle*, a coastwise liner, but to be a fleet scout in war; the *Monterey* and *Comus*, slightly smaller liners, to become district scouts; *Ruel Rowe* to be a mine sweeper; *Lucille Rose* for harbor patrol; together with motor boats of all speeds and sizes for harbor and offshore patrol and scout work.

The secondary batteries of our first-line ships were not complete as to antiaircraft guns, although the construction of these guns was in process.

Work was under way at Pensacola in studying the defense of naval stations against aircraft, both as to location of guns and as to methods of their control.

As to armor-piercing projectiles for Navy use, the capacity of the country was 40,000 per annum of 12-inch and above; the possibilities in the line of producing nonarmor-piercing shell were almost limitless. The reserve stock for the Navy was not yet complete.

The provisions of the department's war plans were being met as fast as funds and manufacturing facilities permitted, the output of the Navy's smokeless powder factory having been pushed by December, 1916, to 22,000 pounds daily from its 16,000 pounds in September, and all ammunition depots were kept busy preparing ammunition for issue to all types of vessels.

Torpedo manufacture was behind, and but little capacity for a production suited to war time necessity existed, but every effort was being made to push work in the fabrication of these delicate and costly weapons. In launching torpedoes from aircraft, the use of a new type of torpedo had been considered, this very small because no seaplanes of sufficient size to carry any of the Navy's torpedoes existed.

In optics, the bureau was having difficulties in obtaining the required number of range finders and binoculars, as well as optical glass for their construction. These necessary instruments were required for all vessels of the fleet, the auxiliaries, the merchantmen, and patrols contemplated by the war plans.

The situation in regard to submarine mines was unsatisfactory, when judged by subsequent events. The only officer on duty with the bureau who was charged with mines had been detached in late December, 1916. The Elia type of firing device was proving unsatisfactory for waters where strong currents existed. Floating mines were being prepared at Newport, and the "depth mine," later known as depth charge, was being put into production, this, however, being only the 50-pound charge, then considered satisfactory in size. The pre-war program called for but 14,000 contact mines, of which 3,232 were on hand. Two thousand, due for completion on February 15, 1917, were under construction at Norfolk, and an additional order was placed for 10,000 at the same place, its capacity being about 500 mines per week at maximum, although the rate being attained at that time was but 140.

The European war had shown that nets were a necessary protection against submarines, and the bureau had experimented with vari-

ous types and placed contracts for one 4,500-foot net for final determination of type. The nets under consideration included towing and trap nets, and, altogether, the bureau had orders placed for some 126,112 feet of steel netting and had included an estimate for Congress for 100 miles of heavy net material and 200 towing nets. The bureau secured on February 6, 1917, the services of Commander S. P. Fullinwider, U. S. Navy, and charged him with direction of mines and nets, which it foresaw must play a most important part in this war.

During the first quarter of 1917, the work of assembling various reserve batteries, acquiring small arms and automatic guns, and assigning guns to merchantmen should they be needed, went on as intensively as supply of materials permitted.

Realizing that the Navy was itself short of machine guns and, thus, could hardly supply the marines who, as a matter of course, would be among the first fighting men to be sent abroad, the bureau, on February 1, wired the various machine gun makers to come to Washington for consultation. This they did, and the chief of bureau asked that they proceed at once with quantity production, deliveries to begin in from 60 to 90 days, orders as to exact quantities would be given later, there being no funds at present. They were asked to "go ahead" and they promptly did so. The Lewis machine gun, which had been used abroad with such excellent results, was modified to fire United States ammunition, and an order for these guns was placed in April, 1917. This early order for machine guns enabled the Navy fully to arm the Marines who went abroad in the first transports, in June, 1917.

On the afternoon of February 3, 1917, the bureau received word that all diplomatic relations with Germany had been severed. A conference of the bureau's officers was at once called and instructions were issued for the procurement of machine guns and certain types of ammunition, and the bureau directed that guns in reserve batteries be shipped to the fitting-out yards of the auxiliary vessels. In one and one-half hours, telegraphic instructions had been sent to all yards to prepare to ship reserve batteries, as indicated in table of August, 1916. The 60 shipment orders were placed at once in the hands of the Bureau of Supplies and Accounts, the necessary letters having previously been typed and placed in the allowance books of the merchant vessels concerned. Thus it was a small matter to sign, date, and mail instructions. Ammunition shipments were made in the same manner. These early shipments comprised some 338 guns from 6-inch to 3-pounders.

It had been demonstrated in 1916 that German submarines could operate successfully at such distances from their bases as to permit

of their crossing the Atlantic and bringing their submarine warfare to our coasts. Defensive measures to guard against this contingency in advance of an actual declaration of war were, therefore, not overlooked. Immediately after the proclamation of the restricted submarine warfare, in the first week of February, 1917, wire rope was obtained from all possible sources in the country and issued to all naval districts and the Army, for use in the construction of net defenses against submarines at our important ports. Instructions as to the fabrication of such nets were issued from the bureau. In a short time the harbors of New York, Norfolk, and Newport were well protected by heavy nets laid across the harbor entrances.

The Council of National Defense during the early months of 1917, established certain subdivisions to coordinate war-like activities, this bureau dealing with the Munitions Board under that body. That board was desirous of obtaining an industrial inventory of the Nation, and found, upon inquiry, that this bureau had anticipated this need by many months, and was able to furnish a complete list of industrial commercial firms, giving their location, capacity, and war responsibilities. This was a confidential compilation of the bureau showing the facilities existing in the United States for the manufacture of projectiles, explosives, guns, cartridge cases, fuses, detonators, torpedoes, mines, nets, optical instruments, and other war materials. All firms were listed by name and address, their capacity and other characteristics being set forth.

In other lines the bureau was ready for war also. It had standard forms of contracts, handled business in a routine manner, and adhered closely to the competitive bidding system for procuring supplies.

Even though money was not available, the bureau knew that, once in the war, America would be there with her whole life and energy, and funds would naturally be forthcoming. Contracts for machine guns as well as for other materials were placed, though covered by no funds. It is a satisfaction to feel that these machine guns played a good part later, and did their share of work overseas, many being fitted on the aircraft which guarded Paris—those that flew to meet and fight the German bombing air squadrons.

Although the President, in an address to Congress on February 26, asked authority to arm our merchantmen—whose voyages took them into seas infested by the piratical German submarines—he failed to receive approval of this measure prior to the adjournment of Congress on March 4. The President declared, on March 9, that he considered he possessed the required authority to arm vessels, and, on March 12, he notified all foreign Governments of his intention to do so. The task of supplying the guns and crews—later known as

"armed guards"—fell to the Navy, which started promptly to work as described in Chapter III.

The various bureau chiefs and assistant chiefs, whose services and whose policies materially aided the 1917–1919 personnel in their endeavors to keep ordnance in the forefront, should fittingly be mentioned here:

Chiefs of bureau:
- Commodore William Mayhew Folger, United States Navy, February 12, 1890, to Janury 2, 1893.
- Commodore William Thomas Sampson, United States Navy, January 28, 1893, to May 31, 1897.
- Rear Admiral Charles O'Neil, United States Navy, June 1, 1897, to March 14, 1904.
- Rear Admiral George Albert Converse, United States Navy, March 15, 1904, to July 31, 1904.
- Rear Admiral Newton Eliphalet Mason, United States Navy, August 1, 1904, to May 21, 1911.
- Rear Admiral Nathan Crook Twining, United States Navy, May 25, 1911, to October 6, 1913.
- Rear Admiral Joseph Strauss, United States Navy, October 21, 1913, to December 22, 1916.

Assistant chiefs of bureau:
- Lieut. F. F. Fletcher, United States Navy, May 6, 1898, to July 7, 1898.
- Lieut. Theodore C. Fenton, United States Navy, July 9, 1898, to October 16, 1901.
- Lieut. Volney O. Chase, United States Navy, October 17, 1901, to January 2, 1904.
- Captain John Hubbard, United States Navy, November 28, 1904, to December 3, 1906.
- Captain Charles W. Bartlett, United States Navy, December 4, 1906, to November 11, 1907.
- Captain Washington I. Chambers, United States Navy, November 12, 1907, to May 31, 1910.
- Commander Edward E. Capehart, United States Navy, June 1, 1910, to August 31, 1911.
- Commander Frank H. Clark, United States Navy, September 11, 1911, to March 19, 1914.
- Commander Charles B. McVay, United States Navy, April 2, 1894, to December 27, 1918.
- Captain Thomas A. Kearney, United States Navy, December 28, 1916, to December 17, 1918.
- Captain Claude C. Bloch, United States Navy, December 18, 1918.

Mr. Edwin S. Brandt has been chief clerk of the bureau since 1898.

To show the progress of ordnance material from the Spanish War to this war, the following comparison is of interest:—

During the Spanish war, 1898, our most powerful vessels were the *Oregon*, *Massachusetts*, and *Indiana*, each armed with four 13-inch 35-caliber guns, eight 8-inch 35-caliber guns, and four 6-inch 40-caliber guns (in addition to a number of smaller guns), and three above-water torpedo tubes. The velocity of the main battery guns of these ships was 2,000 feet per second and an extreme range of 10,000

yards could be obtained. The torpedoes had a range of 800 yards and carried a war-head charge of 118 pounds of wet guncotton. Each of these ships delivered 7,020 pounds of metal per broadside and fired a brown prismatic powder which gave a dense white smoke and obscured the enemy from view. Methods of determining the correct gun range and controlling the fire of this battery of mixed calibers were extremely crude and inaccurate as compared with present-day methods.

In 1917 our latest battleships were the *Pennsylvania* and *Arizona*, whose displacements were about three times that of one of the *Oregon* class and whose battery consisted of twelve 14-inch 45-caliber guns, twenty-two 5-inch 51-caliber guns (reduced during the war to fourteen 5-inch 51-caliber guns) and four 3-inch 50-caliber anti-aircraft guns, with two 21-inch under-water torpedo tubes. One broadside from the main battery of one of these ships delivers 16,800 pounds of metal at a maximum range of 21,000 yards, the initial velocity of these guns being 2,600 feet per second. The guns of the torpedo defense battery (5-inch) fire a shell weighing 50 pounds, at a velocity of 3,150 feet per second, the maximum range being about 13,500 yards. The torpedoes carried by these ships had a range of over 10,000 yards at 27 knots and carried a war-head charge of about 317 pounds of TNT. The projectiles fired by these modern ships are far superior in penetrating qualities to those used by the *Oregon* class in 1898, and are loaded with high explosives and fused to explode in the vitals of a ship after penetrating the side armor. In the same way, the armor of these ships had been increased in thickness and improved in quality, giving greater protection to the personnel and material. Smokeless powder is used as a propellant in all guns and each battery is composed of guns of one caliber. Danger of fires in turrets and magazines has been reduced by air and water systems and by the general arrangement of turrets and handling rooms; so that, in 1917, our latest ships were probably superior to those of any other Navy in this respect. The fire of these batteries is controlled over a system of approximately 220 telephones, fitted especially for that purpose and paralleled by an auxiliary system of voice tubes. The correct gun range is scientifically developed in a plotting room and transmitted to the guns by means of a system of instruments and electrically controlled transmitters, and the guns are fired by the "director system," all guns firing on the closing of one key, thus centralizing the control.

In 1917, one of the latest battleships of the British Navy was the *Queen Elizabeth* armed with 8 15-inch 45-caliber guns, 14 6-inch 50-caliber guns, 2 3-pounder anti-aircraft guns, and 4 submerged torpedo tubes. One broadside from the main and intermediate batteries of this ship delivers a total weight of metal of 14,335 pounds

and develops a muzzle energy of 593,141 foot tons. A broadside from the same batteries of the *Pennsylvania* delivers a total weight of metal of 17,350 pounds and develops a muzzle energy of 826,094 foot tons.

A comparison of these figures with those of early and recent land warfare will give an idea of the development in heavy artillery. At Waterloo, in 1815, 9,044 artillery rounds were fired, having a total weight of 37.3 tons; while on one day, during the last offensive in France, on the British front alone, 943,857 artillery rounds were fired, weighing 18,080 tons—more than 100 times the number of rounds and nearly 540 times the weight of projectiles. Again in the whole of the South African War, 273,000 artillery rounds were fired, weighing approximately 2,800 tons; while, during the whole war in France, on the British front alone, more than 170,000,000 artillery rounds were fired, weighing nearly 3,500,000 tons—622 times the number of rounds and about 1,250 times the weight of projectiles. Six broadsides from the *Queen Elizabeth* or five from the *Pennsylvania* (a broadside meaning the firing of guns bearing on one side only) are about equal in weight of metal delivered in the entire artillery fire at Waterloo.

Thus, the bureau had advanced as constantly and rapidly as had the whole Navy. The bureau had secured a stable smokeless powder, developed armor and projectiles of the finest quality, and the best use possible of moneys allotted it had been made in the years of peace. All material under its cognizance was put to good use when the war came, and nothing had to be discarded or abandoned.

The following tabulated list of the total Navy ordnance appropriations is of interest:

Fiscal year.	Total amount.	Fiscal year.	Total amount.
1898	$8,509,620.00	1909	21,748,116.00
1899	15,946,351.00	1910	24,427,508.00
1900	7,343,124.00	1911	23,413,222.00
1901	6,213,124.00	1912	22,841,005.00
1902	6,701,706.00	1913	20,800,000.00
1903	16,436,206.00	1914	24,927,837.00
1904	13,038,806.00	1915	29,875,890.00
1905	17,875,106.00	1916	31,484,538.00
1906	22,124,506.00	1917	108,452,220.00
1907	22,886,506.00	1918	586,915,267.78
1908	23,935,686.00	1919	352,155,684.50

This indicates how the Navy slowly grew to a position of power and efficiency among the world's navies; in 1916, second only to Great Britain and Germany in actual displacements and numbers; but, in its efficiency, still maintaining a position inferior to none, and with the traditions of bravery and skill that counted for more than men and ships. The spirit of our Navy was its most precious possession, and the war of 1917 amply demonstrated that the soul of the Navy is our country's greatest asset for all time.

CHAPTER II.

THE BUREAU—APRIL, 1917, TO DECEMBER, 1918.

A.—INTERNAL ORGANIZATION.

On April 2, 1917, the President addressed Congress recommending war against Germany; and, at 1.18 p. m., on April 6, the war resolution having been passed by both houses of Congress, he signed the act declaring a state of war with Germany, and issued a proclamation of war.

Austria, acting as an ally of Germany, severed diplomatic relations with the United States immediately afterwards; that is, on April 8, 1917.

The Nation was now at war. The conflict, evident for two months and in probability for many months, was upon us. The Navy was to change from a peace status to a war status. But an efficient navy in peace is maintained in a status as nearly approaching that of war as is possible—as close to a war status as possible—and the moment of transition is imperceptible. So it is with the fleet, and so it was with the bureau. For years the bureau had been operating upon an organization suitable for war, although necessarily much smaller; and, since February, it had been exerting every effort to procure war material, quite as though the Nation were actually at war.

While the bureau's personnel was very small and its quarters cramped, it had a big asset—a basic organization planned and developed by years of experience, one fundamentally based upon war requirements, and never upon those of peace. The principle of this organization was to harness authority and responsibility so that they never could be separated. Whatever success the bureau may have had in the war, was due largely to its adherence to this basic organization. A designer could not design a gun and then throw credit or blame upon the producer, or the latter escape the inspection and the final issue and responsibility therefor. One man was responsible for each bit of material from its start to its completion, then its issue, its service performance, and later its overhaul and repair. Being responsible, he was clothed with the requisite authority over all the details.

Unlike the other first-class naval powers, where most ordnance design originates with the private ordnance firms and is approved by the naval authorities, the design is, in our own Navy, worked up by the department and simply followed by the manufacturers. This condition requires a trained force of seagoing officers for shore duty; this need is efficiently supplied by educating along special lines a few ordnance technicists.

On January 1, 1917, the business of the bureau was handled by but 13 officers and 39 civilians, a total of 52. This number was inadequate, of course, even in peace, and thus the bureau started the war with the big handicap of an overworked personnel which was conducting business in cramped and unsuitable quarters. Good administrative organization made up for much in lack of personnel and space, but the endurance of each was strained quickly beyond physical limits. Due to the basic principles of the bureau's organization, these conditions were easy to relieve when more personnel became available, because of the possibilities for rapid expansion, without changes of duties permitted by it; and this could be done promptly, no matter how many or how great the problems.

The bureau was divided into sections, each technical section under a commissioned officer and each charged with the complete production from design to issue, of a certain class of ordnance material. As the war developed, these sections were enlarged by the addition to each of a number of technical experts, commissioned as reserve officers in the Navy, and the necessary clerical force to handle the greatly increased volume of business. The organization of the bureau as a whole, however, was in nowise affected by this expansion, and the initial organization by sections endured satisfactorily throughout the war, proving the wisdom of its establishment in times of peace. Some few sections were added, as special conditions arose but these merged readily with the main organization.

The accompanying plates show the bureau's pre-war organization, and also the enlarged organization effective in the busiest days of the war. No fundamental difference is apparent. In both, sections charged with guns, turret mounts, powder, torpedoes, armor, supply, fire control, and gun mounts are found. Additional sections for mines, aviation ordnance, and so on, merged readily. An industrial division for the administration of inspections, labor, and patents was formed, but questions under these subjects affecting the details of the production of ordnance material were still directed by the chiefs of the material sections. The various plants, naval stations, and ammunition depots operating under the bureau are shown on the second organization plan, but, though not shown on the first

plan, were as much subject to the bureau, through the same channels, before the war as during it.[1]

The bureau's prewar personnel of but 52 total, inadequate before, was naturally absolutely powerless to handle the mass of business flowing in due to war requirements. Its quarters were changed as noted below, while its personnel was gradually enlarged by taking into the service graduates of scientific schools; and the bureau succeeded in enrolling a splendid lot of officers and enlisted men who enabled it to carry on its war functions properly and expeditiously.

The maximum bureau force was 112 officers, 266 reserve enlisted men and women, and 109 civil-service employees, a total of 487, or 9.4 times its original number.

It is to the credit of the bureau that it never added one officer or man until the need for such additional personnel became a positive necessity. The gradual increase to its maximum officer strength was composed mainly of reserve officers, technicists class 4. The bureau extends its hearty thanks and appreciation to them for services rendered, second to none.

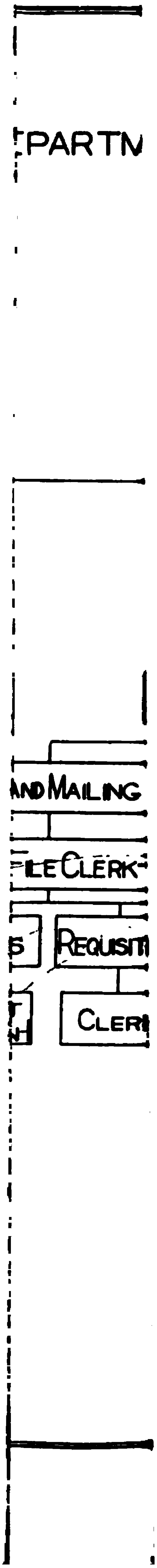
The need of trained officers was always great. Let us hope that the department has learned the lesson, and, in future emergencies, will not be so niggardly with the numbers of personnel. In all lines, more progress would have been made had sufficient personnel been made available when required. The organization was there; it needed but trained men to accomplish the work to be done.

The bureau had no women employees at the opening of the war, but during the war gradually acquired the services of 26 civil-service women and 128 yeomen (F), its first woman employee being Miss Ella C. Leech, yoeman (F), second class, on April 6, 1917. The first civil-service woman was Miss Margaret La Mothe, appointed on September 15, 1917.

During the epidemic of influenza in the fall and winter of 1918, the health of the officers and employees of the bureau continued to be excellent, and the bureau's work was not seriously affected by absences caused by illness of its force from any cause. At one time only were absences from influenza so marked as to cause the bureau uneasiness. This was during the week of October 13, 1918, when there were about 40 persons absent owing to this epidemic. Only

[1] That the policy of this bureau in its development of its organization during the war accords with theory is illustrated by the following extract from the excellent report on the war by Field Marshal Sir Douglas Haig, entitled "Features of the War":

"It may be accepted as a general rule that previous organizations should be upset as little as possible in war. As each war has certain special conditions, so some modification of existing ideas and practices will be necessary, but if our principles are sound these will be few and unimportant. In the present war new organizations and establishments for dealing with the demands of both the fighting and rearward services have been brought into being continually and added to or absorbed by our existing organization and establishment."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three deaths were caused in the bureau's force from influenza. These were Ensign M. H. Barnes, R. F., Mr. Morris Goldman, and Corpl. V. E. Kieber, in charge of the Marine Guard attached to the bureau. The total sick leave taken by the employees of the bureau for the calendar year 1918 was 1,561 days, 312 days of which were taken by four employees during long illnesses. The bureau attributes the good health of its force to the painstaking care of its officers and supervisory employees who required all hands to be careful, and to observe the rules and regulations which were distributed by the Bureau of Medicine and Surgery.

Two important personnel questions had to be handled promptly in the bureau; one was the ascertaining that all its employees were absolutely loyal, the other that of guarding war secrets. So far as the employees were concerned, their loyalty and trustworthiness were in many cases unknown. These were investigated and determined beyond question as satisfactory. It was necessary, for the security of important and confidential matters, and to prevent visits from persons inimical to the Government, to establish a special military guard in the bureau. This was in addition to the very efficient watch force maintained by the civil authorities. The bureau continued this guard until a few weeks after it moved into the New Navy Building. The first guard consisted of seamen, but they were replaced by a force of marines, a guardroom being set aside for them in the bureau; a procedure which enabled the bureau to have military protection at all hours, day and night. This work was done well, and no untoward incidents occurred.

The restricted quarters assigned to the bureau at the outbreak of war in the State, War, and Navy Building have been briefly mentioned. In January, 1917, the bureau occupied 14 rooms with a total of 6,863 square feet of floor space, located on the third floor, east side, of the State, War, and Navy Building. To conduct the business of the bureau in these quarters was simply impossible; and, after much searching for space everywhere, the bureau applied to the Interior Department, and, through the courtesy of the Hon. Franklin K. Lane, the Secretary of the Interior, was granted 46 rooms with a total of 18,400 square feet of floor space, located on the sixth floor, west wing, of the new Interior Building on F and Nineteenth Streets. The removal to these quarters was made on Saturday afternoon and Sunday, May 5 and 6, 1917, the bureau conducting business efficiently in its new quarters on the 7th. This prompt securing of suitable quarters was one of the most essential steps taken to permit the bureau to handle the Navy's needs.

Even these quarters soon became too cramped, and, on October 15, 1918, the bureau moved into 87 rooms of 41,000 square feet of floor

space, located in the new Navy Building, third floor, first and second wings, Seventeenth and B Streets NW.

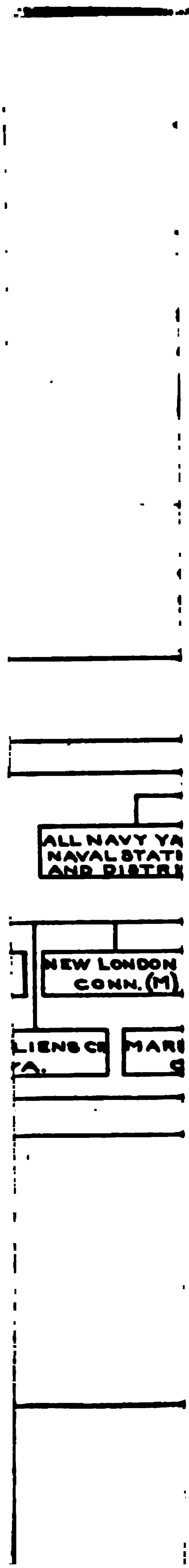
B.—INDUSTRIAL ORGANIZATION.

The Bureau of Ordnance, during the tense period between the date (February 3, 1917), when diplomatic relations with the Imperial German Government were severed, and the date of the resolution of Congress which formally declared a state of war to exist (April 6, 1917), kept accelerating its speed in preparations, the orders placed for munitions indicating, in a measure, this state of affairs. During this time, contracts were placed for 2,600 machine guns, 1,200 1-pounder guns, 1,080 guns of 3-inch caliber, 160 of 4-inch caliber, and 30 of 6-inch caliber. Orders were also placed for the various ammunition details, small arms, mines, nets, bombs, explosives, fuses and primers required for the outfits of the vessels for which these guns were intended and to meet the general requirements of the service.

The stirring events immediately preceding the signing of the armistice so definitely indicate that the 14-inch naval railway battery was a very decisive factor in shattering the German morale, as to point the finger of destiny to the orders placed at this time for high capacity 14-inch projectiles, the first of this type the Navy ever had possessed. A total of 3,850 of these projectiles was then ordered; 782 of these projectiles later definitely figured on the Western Front; one of them, in fact, put a German four-track main line railway out of commission and destroyed two heavily laden enemy troop trains.

During the half year immediately following the declaration of war, the bureau placed contracts for a total of 4,550 guns and for nearly 6,000 gun mounts from 1-pounder to 6-inch caliber; also for 12,350 machine guns, not to mention the millions of rounds of ammunition for these guns, which were necessarily ordered at the same time; for depth charges and mines—both of which played so important a part in overcoming the submarines—and numerous other details of ordnance equipment and supplies.

Upwards of 6,000,000 service projectiles were included in these contracts, and 1,162,400 target projectiles. Of this total of 4,550 guns, contracts for 2,000 4-inch and for 1,370 3-inch, together with 1,145,800 service projectiles and upwards of 1,000,000 target projectiles were placed in advance of June 15, 1917, on which date appropriation was made to cover their cost. The total of the orders, so placed in advance of appropriations, was approximately $66,000,000. The total amount carried by this act for ordnance purposes was $198,066,024, and thus one-third of the appropriation was actually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obligated in advance of the date of approval of the act making the funds available.

It was soon evident that to obtain the production required without interference with the Allies, or the Army, was no easy matter. Frequent conferences took place in an endeavor to allocate plants or to regulate their deliveries so that all would share alike.

Among the early decisions made was this—that the Midvale plant would make armor-piercing shells for the Navy, which branch of the Government would not expect such from Bethlehem. This decision resulted partly because the latter company had been unable to manufacture large shell of sufficiently good quality to pass the rigid Navy tests—the severity of which were never relaxed in any particular during the war, even to permit quicker deliveries—but mainly because the Army preferred to have the principal control of the affairs of one large shell plant.

A certain portion of Midvale's forging facilities were agreed upon as belonging to the Navy, the latter asking practically nothing from Bethlehem, that company devoting its energies solely to the Army work.

The contracts for explosives, powder and shell, as well as those for forgings, were placed in accordance with the approved recommendation of a joint Army and Navy board made on March 17, 1917, allocating plants or portions of plant capacity to either the Army or Navy.

The many new firms, that were started in gun and munition making, collaborated in an effort to discover each other's faults, showing the remedies, and thus speeding up. To maintain this in a workable system, the Gun Howitzer Production Club with Mr. A. A. Stevenson of the Standard Steel Works as president, was formed; the bureau's members thereon being Rear Admiral Ralph Earle, Lieut. Commander N. W. Pickering, (relieved later by Commander A. C. Pickens), Lieut. W. I. Howland, jr. (relieved later by Lieut. Commander A. G. Zimmerman) and Commander J. B. Rhodes, of the big Naval Ordnance Plant under construction at South Charleston, W. Va. As an example of one of the difficulties, boring mills were hard to obtain, and their lack rather limited the supply of forgings, but this committee, by comparative studies in speeds of boring, materially systematized the processes and speeded up work, reducing boring times of rough forgings by 50 per cent.

The quality of and routine inspection for gun forgings were made uniform by Navy and Army with joint specifications, drawn up with great care after many discussions as to how to modify existing ones, in order to retain the high quality required, but nevertheless to increase the speed of production.

Among the bureau's wise and fore-sighted measures in this war period was the effort made by it, alone, to secure the enactment of a law, by which Congress authorized advance payments to contractors of a sum not exceeding 30 per cent of the contracts awarded them. This provision was most necessary, and its enactment certainly saved the day for Navy ordnance.

As a result of the bureau's urgent recommendations, the deficiency act of October 6, 1917, provided for advanced payments in the following language:

SEC. 5. That the Secretary of War and the Secretary of the Navy are authorized, during the period of the existing emergency, from appropriations available therefor, to advance payments to contractors for supplies for their respective departments in amounts not exceeding thirty per centum of the contract price of such supplies: *Provided*, That such advances shall be made upon such terms as the Secretary of War, and the Secretary of the Navy, respectively, shall prescribe, and they shall require adequate security for the protection of the Government for the payments as made.

Without the aid of this law, there were few new firms that could, by any possibility, enter the field of manufacture of ordnance; and yet new firms had to take up such work, else merchantmen, destroyers, and patrols would have been without guns.

A gun is not a thing to be built hurriedly; it can not be builded in a day. Expensive machinery, furnaces, cranes, lathes, buildings to house the same, power to operate them, and so on, must first be provided, and many, many months, some 6 to 18, depending on size, are required to obtain a gun or its mount, and this time can not be reduced, even should limitless funds be available and these be used most extravagantly. The Bureau of Ordnance had to look forward, always, toward the demands of war, and, naturally, it was doing its utmost to secure replacement guns, refills of ammunition. reserves of torpedoes and mines. Men and ships could be provided far faster than could guns and other offensive weapons.

This law of Congress really saved the convoy system, made it a success, enabled destroyers and transports to be armed; without it, the Navy could never have had its clean record of transportation of men and supplies overseas.

In the effort to obtain additional capacities for ordnance manufacture, the bureau found that, in addition to encouraging new firms by advance payments, in order that they might finance such projects, it was obliged, also, to go to the method of cost-plus contracts, much against its desire. The major portion of the bureau's contracts had been on a fixed-price basis, the price being determined as the result of competitive bidding, but there came a time when major contracts could no longer be placed in this manner.

A canvass was made of the plants thought to be capable of manufacturing war material. Conferences were held, and where plants

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were found with the necessary organization and management but, through lack of capital or other reasons, were unable to take a straight contract, a cost-plus contract was entered into with them. It should be borne in mind that some of these contracts required large outlays of capital before a stroke of work could be done. Especially was this the case of the Erie Forge Co., who were to manufacture gun forgings and destroyer shaftings, and where four and a half million dollars was advanced. With the Hun submarine ever present, all transports and cargo carriers, these increasing in numbers rapidly, required guns, and with an ever-pressing demand for more guns, and for still more guns, it became imperative for the bureau to take advantage of every possible means of meeting this condition. Contractors, in offering their services, generally were imbued with the highest patriotism, and desired to do what the bureau pointed out to them that they could and ought to do.

The General Munitions Board of the Council of National Defense was created on April 9, 1917, with Mr. F. A. Scott, of the Warner-Swasey Co., as its chairman. Representatives of all the bureaus attended its meetings as members; Capt. T. A. Kearney ably acted for the Bureau of Ordnance. The priority of orders became a burning question, and on May 14, 1917, a large priorities committee of this board, with Maj. Gen. James B. Aleshire, United States Army (retired), as chairman, was formed. Rear Admiral N. E. Mason, United States Navy (retired), who was the chief of bureau from August 1, 1904, to May 31, 1911, was assigned, in addition to his duties in the bureau, as the ordnance member of this committee; he had as his principal assistant Lieut. J. M. Blankenship, United States Navy. The priority committee of the Munitions Board adjusted satisfactorily practically all cases of conflicting deliveries, which in the beginning amounted to from 30 to 40 per day, but by August, 1917, they were averaging 75 per day. Some reports have been current that Government departments bid against each other, but such was certainly not the case. This bureau found that its desire to play fair was equaled always by that of the Allies, other Government departments, and the contractors. Close touch was maintained with all, and friction was certainly slight.

The War Industries Board was formed on July 28, 1917, and the priorities committee then came under Judge R. S. Lovett. The work of issuing priority certificates continued. Additional powers were conferred upon Judge Lovett by agreement of Army, Navy, Shipping Board and Emergency Fleet Corporation. By means of subdividing the committee, all our own and our Allies' priorities were handled to the contentment of all. The first priority certificate was issued September 25, 1917, and since then some 191,966 were issued

funds required to carry on work at the numerous Government plants, the securing of priorities, and the commandeering of property.

The speeding up of industrial effort, with a view to maximum production of ordnance materials in the shortest practicable time, formed the basis of far-reaching financial questions, admitting of no delay, if the purpose of this effort was to be fully met. In other words, all other considerations were required to be subordinated to minimizing the time factor. Partial payments under contracts were authorized by the act of August 22, 1911. Predicated on this act, various methods were devised by the bureau for financing work under ordnance contracts, according to the particular needs of each of the various contractors and their operating methods. What may be termed an analytical method for such payments was instrumental in producing such satisfactory results as to suggest special mention. Any given device covered by contract was scheduled as to its several parts, to each of which was assigned its relative value or portion of the contract price. Partial payments were predicated on these values as the work on each part progressed, thus permitting completion of the whole quantity required of any particular part on a production basis without undue financial burden to the contractor, pending the time when completed units could be submitted, tested, accepted, and paid for. The making of partial payments thus became a matter of routine, as simple as the keeping of records of stock on which they were based.

In entering into cost-plus contracts, the bureau agreed to pay for the cost and installation of all the necessary machinery and equipment, and of temporary structures, all of which became the property of the United States Government. All machinery and tools were marked with a brass plate—"Property of the U. S.: purchased ————". Articles, too small to be marked with a plate, were stamped with a die "U. S. N." It also agreed to pay the cost of all labor and material, and a proper proportion of overhead expenses. Before ordering the machinery and equipment, conferences were held with the technical officers of the bureau, and thus the number and class of machines to be bought was decided.

On September 8, 1917, Commander John H. Moore, U. S. Navy reported for duty in the Bureau of Ordnance, and was placed in charge of these cost-plus contracts.

An ordnance cost board was created, consisting of the chiefs of the Bureaus of Ordnance and Supplies and Accounts. This board had the final decision upon all questions in dispute. It was represented at each plant by an inspector of ordnance and by a cost inspector. All articles going into the plant were purchased by the contractor, being paid for under a plant or material order. Weekly reports

were required from the naval inspector as to the progress of the work, and the technical officer in the bureau in charge of the same made occasional inspections. The schedules of wages paid at the plants were approved by the Navy Department in all cases, before they became effective, and also the salaries of the officers, which were borne in the overhead expense.

Profits were not excessive. On gun forgings, 5.8 cents per pound for the 3-inch guns and 4.5 cents per pound for the 4-inch guns. For 3-inch antiaircraft guns, $225 for each gun, complete, with breech mechanism. For 4-inch guns, $400 per gun complete, and for 5-inch guns, $485 per gun complete. On smaller contracts a net profit was allowed between 10 and 15 per cent.

Upon the signing of the armistice, all cost-plus contracts were either canceled outright or notifications were given that they would be canceled upon completion of certain work.

In all contracts there was a cancellation clause and provisions by which the contractor was to take over the entire plant or portion thereof. For instance, the Poole Engineering & Machine Co. were obligated to take over the entire plant and equipment at 66⅔ per cent of actual cost. Others are to pay from 40 to 60 per cent for cost of buildings, leaving the equipment for later adjustment.

Full and by, the bureau was able to make quite satisfactory arrangements for its investment in buildings and equipment, varying with the previous work of the contractor and his ability to make use of same later.

The following is a list of the principal cost-plus contracts entered into by the Bureau of Ordnance:

Erie Forge & Steel Co	4-inch gun forgings.
Alloy Steel Forging Co	Do.
Inland Ordnance Co	3-inch and 4-inch gun forgings.
Tioga Steel & Iron Co	4-inch gun forgings.
Poole Engineering & Machine Co	500 4-inch guns complete.
Bridgeport Projectile Co	146 5-inch, Mark VIII, guns complete.
American Radiator Co	1,000 4-inch guns complete.
Four Lakes Ordnance Co	500 5-inch, Mark VIII, guns complete.
Defiance Machine Works	500 3-inch, Mark XAA, guns complete.
E. I. du Pont DeNemours Co	Acid and nitrating plants.
J. G. White Engineering Corp	Nitrate plant.
L. E. Knott Apparatus Co	K-1 devices for mines.
H. E. Boucher Mfg. Co	Do.
Ordnance Engineering Corp	Star shells.
Olympian Motors Co	Aerial bombs.
Recording & Computing Machine Co	Directorscopes.
Waterbury Tool Co	Turret gears.
Gundlach Manhattan Optical Co	Lenses.
Aetna Explosives Co	Trinitrotoluol.

Petroleum Iron Work Co. of Ohio	Parts of mines.
John A. Roebling Sons & Co	Do.
Wagner Electric Manufacturing Co	Do.
The Pressed Steel Tank Co	Do.
Sperry Gyroscope Co	Experimental development of certain confidential devices.

The total amount of the contracts made during this period for special ordnance materials—contracts for guns, gun mounts, projectiles, torpedoes, and other necessary articles including both contracts made by the department and administered directly by the Bureau of Ordnance, and those made by the Bureau of Supplies and Accounts on the basis of this bureau's specifications and requisitions—was not far from $800,000,000, approximately one-half being departmental contracts and one-half purchases by the Bureau of Supplies and Accounts. Special attention was given to the preparation of vouchers for materials under these departmental contracts which resulted in payments being generally received by the contractors within 10 days of the time the original vouchers were prepared—sometimes less than one-half this time elapsed between the time the progress of work warranted payment and the time payment check was received. This result seems to have been largely due to the fact that vouchering was systematized on the "production" basis the same as manufacturing is accomplished in an up-to-date modern plant. The frequent appreciative comment made by contractors on the promptness of Navy Ordnance in meeting its financial obligations is believed to reflect the real benefit derived from this condition. Production was required and effected far beyond the normal capacity of many plants.

During this period $100,000,000 of ordnance funds was expended at navy yards and stations for labor and for materials. In accordance with the act of March 3, 1905, which penalizes deficiencies, these expenditures were necessarily covered by previously made monthly allotments.

Prior to the war, there were but three people in the bureau's financial section. Nineteen was the highest number at any one time in the section during the war, although a total of 34 was on its roster during this period. This section was in charge of Mr. W. W. Werntz, who had for some time previously performed the same general duties in the bureau, Mr. Frank S. Ray being his principal assistant.

The aggregate salary paid to employees of the bureau handling the administrative generalities and essential details of these departmental contracts, and much of that under other purchase contracts, aggregating approximately $800,000,000, was but $35,972.69 for the period April, 1917, to July, 1919, or but 4½ cents per $1,000 of the value of the contracts.

All material purchased through the Bureau of Supplies and Accounts was made the subject of requisition by the bureau, or by the navy yard, or office requiring it. These requisitions were required to give as complete specifications as practicable for the material wanted, in order that all responsible firms which handled the material in question, might be in position to bid with the assurance that they understood exactly what was required. Owing to the special needs of the Naval Service, special material was frequently required; but it was the aim to buy material conforming, as closely to recognized engineering or commercial standards and specifications, as the special needs of the service would permit.

The following table shows the number of requisitions handled during the fiscal years 1916, 1917, 1918, and 1919. Immediately after the armistice was signed, there was a decided falling off in the number of requisitions received, which accounts for the reduced number handled during the fiscal year 1919.

Fiscal year.	Naval supplies and accounts requisitions.	Ordnance requisitions.	Ship's requisitions.	Total.
1916	1,700	1,329	2,240	5,269
1917	1,865	1,867	2,975	6,707
1918	5,529	2,710	4,066	12,305
1919	5,033	2,748	3,148	10,929

Requisitions were handled by a section headed by Mr. F. B. Blackburn.

In January, 1918, the conduct of the affairs of the Bureau of Ordnance was investigated by a subcommittee of the House Committee on Naval Affairs under the chairmanship of the Hon. W. B. Oliver. This committee, during January, went thoroughly into all phases of the bureau's administration of war activities, and found that all appropriations had been expended or obligated with judgment, caution, and economy. The report of the committee, dated March 11, 1918, gave encouragement and renewed energies to the bureau's personnel, and it is but fair to state that many helpful ideas and suggestions were given by the committee, and taken advantage of by the bureau, which has always found this important committee most friendly in its dealings with the bureau. In all its hearings before this committee of Congress, the bureau records with pleasure that it has met with most unfailing courtesy, painstaking effort to assist, while guarding the finances of the Government, and considers that the appropriations allowed it during the war period were sufficient to permit the bureau full use of its initiative in producing munitions for war.

In round numbers, it is thus seen that the Bureau of Ordnance spent during the war approximately $810,600,000; and, as it is of general interest how this amount was divided, an approximation is herewith given. This can not be exact at the present time, as many of the contracts involved are not settled or final payments made.

The main expenditures then will be found in the items as follows:

Guns	$100,000,000
Gun mounts	115,000,000
Service projectiles	110,000,000
Target projectiles	6,000,000
Torpedoes	38,000,000
Depth charge projectors	2,240,000
Director system	3,380,000
14-inch railway battery	3,000,000
7-inch tractor mounts	1,500,000
Fire control and optical instruments	15,500,000
Machine guns and small arms	21,000,000
Mines	30,500,000
Mines, mine bases abroad	4,500,000
Depth charges	2,000,000
Nets	4,000,000
Smokeless powder	47,400,000
Nitrate and acid plants	3,300,000
High explosives	70,000,000
Ammunition details (general)	100,000,000
Machinery, tools, etc	26,000,000
Labor and material at navy yards and stations in upkeep, repair, and modernizing vessels of the fleet, auxiliaries, patrols, and transports	100,000,000
Armor	7,280,000
Total	810,600,000

D.—RECORDS AND MAIL.

Some years previous to the war the bureau had adopted a standard filing system and had a section devoted to files and mail. With the expansion due to the war this, like other sections, proved satisfactory in organization and, although greatly taxed at times, kept adequate record of the enormous mass of business in the bureau in the times of greatest pressure.

On April 6, 1917, the file room force consisted of eight clerks in charge of Thos. S. Scrivener and Albert S. Brown, all quartered in one room in the State, War, and Navy Building. On May 5, 1917, when the bureau moved into the new Interior Department Building, the space assigned to the file room was very satisfactory for a short time, but this, as the force was gradually augmented to 40 clerks, became overcrowded, and the correspondence was so heavy, as well as urgent, that the force was divided into two shifts, thus giving

continuous service from 8.30 a. m. to 11.30 p. m. By this system the work was handled on time. This plan was discontinued on November 5, 1918, and prewar working hours were again put into force. The force worked strenuously, kept always up to date, and won the praise of all who depended upon it for information and other assistance. During the war a number of the file room employees, who had been partly trained, were withdrawn and diverted to other duties in and out of the bureau, many becoming paymasters, and the training they had received made them valuable in their new positions.

Prior to the war, the bureau's outgoing mail amounted to an average of 106 letters each day. The average letters mailed from the bureau increased to approximately 375 daily during the fiscal years 1917 and 1918. This figure does not include copies of letters, circular letters, bills, requisitions, travel claims, separate cover inclosures, or registered mail. In addition to this, the figures do not include the vast amount of printed literature, such as ordnance forms and ordnance pamphlets distributed to the ships and stations under the Naval Establishment, also confidential and secret mail, the handling of which requires much additional care and time. A force of seven men, under Chief Yeoman F. S. Hudson, R. F., was required for the mail duties in the war period. Since the cessation of hostilities the work of the mail room has decreased 33 per cent.

CHAPTER III.

ARMING VESSELS.

The submarine warfare of the Germans may be logically divided into four principal periods covering the entire duration of the war from August, 1914, until the signing of the armistice on November 11, 1918.

The first of these periods, and by far the longest one, extended from August, 1914, to the spring of 1916. During this period of about two years, merchantmen and other ships were for the most part unarmed, and but few of the submarines carried guns. The great weapon of the submarine during all of that time was the torpedo, and, when sinking without warning was not indulged in, it was the procedure suddenly to appear alongside of a vessel, command her to stop, force the crew to take to the boats and then sink the ship either by a torpedo or by bombs. The absence of a gun of any size on board the submarine forced her to rely on her power of submergence for defense, and on the periscope for her sole means of vision. Consequently, the earlier type of submarine was to a large extent helpless, when it encountered vigorously defensive tactics on the part of the merchant ship it attempted to stop. Monthly sinkings for the first period of the war averaged between 60,000 and 70,000 tons.

With the commencement of the arming of merchant cargo ships for defensive purposes, we enter upon a second period in the submarine war, which was to last until the summer of 1917. The latter part of the first period presaged a vigorous policy of defense against the undersea pirates. Guns were supplied and the masters of the vessels took every means in their power to escape the submarine. The submarine, therefore, no longer enjoyed immunity from attack by the vessels on which it called for surrender and the natural outcome was a policy by the Germans of arming their submarines, and the adoption, to a greater extent than ever before, of a policy of unrestricted sinkings. In the spring of 1916, then, there started the race between the offensive measures of the submarines on the one hand and the offensive and defensive measures of the Allies on the other.

Although the Germans did not make a formal declaration of their policy of sinking without warning and without regard to the laws of the seas and humanity, until February, 1917, they had, neverthe-

KING GEORGE ON BOARD THE ARMED LINER SAN JACINTO.

MOUNT VERNON.

less, for a number of months previously increased the numbers of their sinkings of this purely piratical type. A curve of the tonnage they destroyed shows that all during the second period losses kept steadily increasing, starting with an average tonnage of around 100,000 tons per month in the spring of 1916 to an average of over 500,000 tons per month in the early spring of 1917, when the United States entered the war.

April, 1917, marked a peak in the German destruction of shipping, for in that month they destroyed a total of 870,000 tons. The entrance of the United States into the war, by changing the attitude of this country from that of a neutral nation to that of a belligerent, was responsible to a large extent for the organization of all the offensive and defensive measures of the Allies into a cohesive unit. It removed all restrictions on the arming of ships, transports, merchantmen, and paved the way for the introduction of the convoy system. In short, it placed the merchant marine on a fighting basis and under Navy control.

This change did not come a moment too soon. The armament of submarines had gradually increased and grown, so that the submarine was no longer helpless when on the surface but was indeed a very formidable antagonist.

Submarine sinkings continued at the rate of 600,000 tons per month until the summer of 1917. Then a third period began, when the steps taken in arming merchant ships and in convoying them across the Atlantic produced a drop in the tonnage sunk to a figure in the neighborhood of 400,000 tons per month, and sinkings continued at this rate until the spring of 1918.

Then, however, the fourth period, wherein the submarine was finally defeated, was ushered in by the development of the later ordnance weapons, such as the depth charge and the Y-gun, the final perfection of the organization of submarine hunting and destroying devices, the mining of the English Channel, and, finally, the great project of extending a complete barrier of mines entirely across the North Sea. By the cumulative effect of all these offensive measures, the submarine losses dropped to 200,000 tons per month at the time of the signing of the armistice, and complete defeat of the submarine warfare was assured.

Running through all the later stages of the submarine war, from before the actual entrance of the United States into the war until the actual signing of the armistice, the history of our own merchant marine shows an effective record of combat against the undersea enemy.

The arming of these vessels was not the achievement of a moment, but rather the result of concentrated and continued effort. Guns

can not be made over night; many times the bureau was on the point of complete exhaustion of weapons for our ships; but was always able to keep just that one gun or one battery ahead which insured that no ship would be kept waiting for arms or forced to go to sea without them.

After the declaration of unrestricted submarine warfare, there was considerable agitation in this country as to whether our merchant vessels should be armed for their preservation, or whether our continued neutrality required that they should sail the seas unarmed and defenseless against the submarine. National pride and national defense triumphed over passive neutrality.

March 12, 1917, will be always remembered as the date on which the Navy decided to arm offensively against the submarine all merchant vessels whose voyage carried them into the danger zone.

On the 13th of March, 1917, the Secretary of the Navy issued regulations governing the conduct of American merchant vessels, on which Navy personnel to man the guns, designated as Armed Guards, were to be placed for the protection of the vessels, their crews and cargoes.

Thus, one of the first problems which confronted the bureau was how to obtain guns to arm the immense number of merchantmen, a number far in excess of anything ever contemplated by war plans. Then, too, the numberless craft of all sizes and types that were acquired rapidly by the Navy for patrol purposes must be armed.

Later came the big building program of subchasers and destroyers, beginning, respectively, in July, 1917, and October, 1917, which could be laid down and built at many different yards. The Bureau of Ordnance could not manufacture guns fast enough to keep up with this new construction, as the large presses and furnaces required in their construction could not be built in a time anywhere near the equal or comparable to that in which subchasers or destroyers could be built, the new facilities requisite for this latter work being easily and quickly provided.

When providing guns for vessels, it was necessary that instructions be issued as to their operation. Also, the bureau had to keep files of and trace all shipment orders, maintaining a record of all docking schedules and ship movements. Ordnance material for the vessels engaged in patrol and antisubmarine work included, in addition to guns and ammunition, the new Y-guns, the depth charges, and spare parts of all descriptions.

Directions assigning guns to the *Manchuria*, *Mongolia*, *New York*, *Philadelphia*, *Kroonland*, *St. Paul*, and *St. Louis* were issued by the Bureau of Ordnance on March 13, 1917, and on the following day batteries were assigned to the *West Oil*, *Aztec*, and *Campana*. The work of installing the guns on the *Manchuria*, *St. Louis*, and *Aztec*

was completed at the navy yard, New York, on the 15th of March, and, by the 19th of that month, the *New York* and *St. Paul* had their batteries completely installed.

The first armed merchantmen to sail for the danger zone was the *Manchuria* sailing from New York on the morning of March 16, 1917. Her battery consisted of one 6-inch 45-caliber gun and two 3-inch 50-caliber guns.

The *Aztec*, armed with two 3-inch 50-caliber guns, sailed on March 17 for Havre, France, which port she never reached, being sunk off Ushant at 9 p. m. on April 1, 1917. She was the first American merchantman with armed guard aboard to be sunk. Lieut. W. F. Gresham, U. S. Navy, the commanding officer of guard, was the executive officer of the Secretary of the Navy's gunboat *Dolphin*.

The first armed merchantman to reach an overseas port, although the third to sail from the United States, was the *St. Louis*, a vessel of the American Line. This vessel's name was shortly afterwards changed to *Louisville*. Her battery consisted of three 6-inch 45-caliber guns which were installed on March 15, 1917, at New York. She sailed at 1 p. m., March 18, and arrived at Liverpool on the afternoon of March 26.

When the President authorized the arming of merchant ships, the Navy had only 876 guns, ranging from 3-inch 50-caliber to 6-inch 45-caliber, that were not actually in service on vessels of the Navy. These few guns were not all immediately available for issue, some being in the possession of Naval Militia organizations and others in navy yards on the Pacific coast, in which case it was necessary to ship them across the continent.

Naturally, as such a contingency had never been recognized as likely to exist, the supply of guns available for merchant vessels was totally inadequate, and, on March 27, the removal of thirty-eight 3-inch 50-caliber guns from cruisers and the older battleships was authorized by the department upon recommendation of this bureau, these guns being utilized at once for arming merchantmen. It was rightly believed that the guns in question, if left aboard such vessels, would never be used in the war. The sinking of the *Hogue*, *Cressy*, and *Aboukir* on September 22, 1914, in the North Sea off the Hook of Holland by the German submarine *U-9*, had emphasized the desirability of eliminating gun-deck port openings, which are a source of danger when a ship lists heavily to one side after being torpedoed or mined, and so a certain proportion of guns could wisely be spared. The removal of the guns permitted the sealing up of these dangerous openings, and was, therefore, no loss in military efficiency to the Navy, rather a gain.

The declaration of war on April 6, 1917, made it further necessary to supply guns for transports, supply ships, and vessels that

were to be armed to patrol the Atlantic coast. All these demands had to be met, in addition to the rapidly-increasing demands for merchantmen, but the supply of guns was inadequate for even the least of these requirements. However, it was essential that these vessels be armed; and, on April 26, 1917, the Bureau of Ordnance obtained authority to remove one hundred and twenty-four 3-inch 50-caliber, twelve 4-inch 40-caliber, twelve 5-inch 50 caliber, and thirty-six 6-inch 50-caliber, or a total of 184 guns and mounts from the least advantageous locations on battleships and cruisers. These were all selected in accordance with the policy and for the reasons just indicated. Again, on April 28, 1917, authority for the removal of 180 more 3-inch 50-caliber guns was obtained in order that the work of arming merchant ships might continue without interruption. This policy of the department, which really was putting what it had to the best possible use in the quickest time, gave the bureau a start in arming merchantmen.

In addition to the guns removed from vessels in active service, the 6-inch 50-caliber and 3-inch 50-caliber guns of the cruisers *Memphis*, stranded on the Dominican coast, and the *Milwaukee*, ashore off California, were salvaged, sent to the Naval Gun Factory at Washington, there overhauled and placed in service again on merchantmen and transports in the quickest possible time.

There were also new guns near completion at the Naval Gun Factory allocated for vessels of the Navy still under construction, and such guns were taken to help fill the most urgent demands for the protection of American shipping. At that time the guns being built by contractors were in most cases far from being ready for delivery, and although contracts were placed promptly with every contractor that had previously built guns for the Navy and many new plants for the manufacture of guns for the Navy were under way, it was not possible that deliveries, in anything like sufficient quantities to meet the demands, could be made before the summer of 1918, at the earliest. Of all war munitions, the fabrication of high-powered naval guns and mounts requires the longest time and necessitates the greatest preliminary preparation. Therefore it was necessary to take the number of guns from vessels in service as outlined above. In no case, however, were guns removed where the conditions of sea warfare warranted their retention. In fact, even since the close of hostilities, guns have been removed from dreadnaughts because sea and spray interfered with their successful handling when cruising at the high speeds essential in modern naval battles.

When the guns were procured, it was necessary to transport them over traffic-laden, congested roads to the various shipping centers on the Atlantic Coast and install them on the vessels that were carrying

troops, food and other supplies to Europe, and to do all of this work without delaying the vessels. Europe needed men and supplies, and the Navy armed the carriers while they were unloading and loading. The problem of transporting guns to the points required was worked out in cooperation with the Bureau of Supplies and Accounts. The installation of the guns was a large undertaking as strong foundations and extra deck supports had to be provided on the vessels, they not having been constructed for carrying guns, and all foundations must be built sufficiently rugged to prevent the opening of seams when the guns were fired. In addition, guns must be located in positions that would give the maximum arc of fire. This problem was successfully solved by our naval constructors of the Bureau of Construction and Repair, and the work of actually installing the guns was effected at any time the ships were in port; day and night alike the gangs at the navy yards worked to give the merchantmen protection, with the result that there never was a delay in the flow of supplies to Europe due to waiting for guns or ammunition.

At the port of New York, more guns were installed on merchant vessels during the war than in any other port in the United States, and here Lieut. Commander R. W. Clark, ordnance superintendent at the navy yard, New York, by his efficiency and untiring energy, did the work of arming vessels. Lieut. Commanders H. T. Kays and P. B. Haines at Philadelphia, A. H. Miles at Norfolk, and H. H. Norton, in charge of the Armed Guard Office at New York, were zealous in their duties in charge of outfitting armed guard vessels for service in the war zone.

The work of the Bureau of Construction and Repair, in addition to preparing the gun foundations, included the construction of certain bulkheads so as to provide compartments for stowage of ammunition, passing scuttles, whips, and ready ammunition chests on deck, and voice tubes to carry the fire control orders to crews of the guns. The Bureau of Steam Engineering fitted call bells for voice tubes, and provided the necessary telephones, all of which work was practically as necessary as the installation of the guns. It is needless to remark that these bureaus, in accordance with their usual traditional customs, were always on their mettle and prompt to the minute with all this work.

By the 1st of October, 1917, the supply of guns was again near exhaustion. The Naval Gun Factory continued to deliver a few guns, 3-inch, 4-inch, and 5-inch; and they were placed in service as rapidly as they were completed. The demands for guns were increasing all the time, so, on October 4, 1917, orders were issued for the removal of 28 3-inch 50-caliber, 26 5-inch 51-caliber, and 2 4-inch 40-caliber

guns in addition to those already removed from cruisers and battleships.

Those guns, with the few remaining on hand at the navy yards, carried the bureau over until December 7, 1917, when it again became necessary to go to the fleet for guns, and this time 20 5-inch 51-caliber, 20 6-inch 50-caliber, 4 5-inch 50-caliber, and 26 3-inch 50-caliber guns were taken. The first deliveries under war contracts of guns (4-inch) were made by the Root & Van Dervoort Engineering Co. in April, 1918, and of gun mounts (4-inch) by the Linderman Steel and Machinery Co. of Muskegon, Mich., in January, 1918. Thus it is seen that 9 months was about the shortest time after an order was placed in which even a small naval gun could be produced.

To arm patrol vessels quickly, orders were placed for Davis nonrecoil 3-inch guns. The lightness and nonrecoil feature of the gun enabled the bureau to place on small vessels, a gun large enough to do real damage to a submarine. Again, in a similar effort to equip the new 110-foot subchasers, authorized by the department, with a gun that would do real damage, the bureau had designed a 3-inch 23-caliber gun and mount, both of an entirely new type. This work was done in record time by the Poole Engineering and Machine Co. of Woodberry, near Baltimore, and large orders were placed with this and other companies. Although ordered in March, no deliveries could be expected until September.

At first, it had appeared as if the merchantmen requiring guns would number comparatively few, and, therefore, from three to six guns were supplied each vessel, thus making them as offensively powerful as practicable. This not only depleted the supply of guns rapidly, and called for an excessively large number of officers and men of the Navy to man them, but also interfered in large degree with the deck space for cargo handling. In fact, it was very difficult to find locations clear of the rigging from which the guns could be operated efficiently and where moderate seas would not wash over them. For these reasons the department decided on November 7, 1917, to adhere to standard armament of two guns, a 3-inch 50-caliber forward and a heavier gun aft. This decision was logical and proper from all points of view, and worked out well during the war.

The Italian Navy requested, in the latter part of 1917, long-range guns to help them withstand the assaults of the Austrians led by Germans along the Piave, which attacks were directed at Venice. The Italian Navy manned about 250 naval guns, operating with their Army in the critical days after the Caporetto retreat. Our Navy, therefore, furnished the Italian Navy ten 5-inch 51-caliber naval

STERN OF THE U. S. S. VON STEUBEN, SHOWING AFTER GUNS.

U. S. S. LEVIATHAN, SHOWING BOW GUNS.

44-2

guns of long range and high power. In addition, the bureau was primarily instrumental in placing many machine guns, with ammunition, in the hands of the Italian troops at this critical time.

Many merchant ships operating under British, Russian, French, Belgian, Portuguese, and Cuban flags were supplied with guns despite the shortage or, rather, lack of reserve that existed in our own country. Of guns of 3-inch 50-caliber, 4-inch 50-caliber, and 5-inch 51-caliber, the bureau supplied 62 to meet such needs. Of the 3-inch 23-caliber guns, 92 were supplied the French patrol vessels, mainly for the 110-foot sub-chasers.

One of the most difficult tasks was to insure that merchantmen and auxiliaries had a satisfactory supply of the ordnance accessories and the spare gun and breech mechanism parts, so vital to efficient operation of guns at sea. When installed on ships of the Navy, acaccessories and spare parts provided for every four guns were sufficient. As merchantmen mounted two guns, usually, and these of different calibers, it was essential that accessories and spare parts for every such gun be supplied. The bureau managed to do this, but solely because it could direct the output of that most modern and progressive ordnance plant, the Naval Gun Factory, located in Washington, D. C., on the Anacostia River. These parts, of many different kinds and sizes, amounted to a number under order of over 66,000 at one time, and 20,000 items of this nature was the least number on order at that plant at any period.

The larger Coast Guard cutters that had joined the Navy had been armed by it with four 3-inch 50-caliber guns each. There were also a large number of yachts taken over by the Navy, and each was armed with two, three, or four 3-inch 50-caliber guns. Certainly, many times, it seemed as if the task of supplying the guns as fast as they were required was impossible, and the tension in the bureau and its plants was not little.

The vessels engaged in transporting men and overseas supplies to the western front had to have guns, and the bureau saw to it that they obtained them. About the beginning of 1918 there were times when there were not a dozen guns in the Navy that were not in service, and the bureau was receiving calls for guns and more guns every day and almost every hour. The few 5-inch and smaller guns that were completed by the Naval Gun Factory each month and the guns taken from the fleet, with the new ones coming in slowly, kept just even with the most urgent demands.

This demand for guns grew more urgent during the first six months of 1918, as new ships were being completed by every shipbuilding company in the United States, and the volume of guns coming from contractors had not yet become large. The ships of the

fleet had given the bureau every gun that they considered could be spared without reducing their efficiency as fighting units. By June, 1918, although the number of guns being delivered by contractors was increasing each month, and they were rushed through proof and every advantage was taken of the right of way given by the railroads to war materials, the Bureau of Ordnance was barely able to meet the demands. In July, August, and September, 1918, even with the increased output of guns and mounts by contractors and those taken from the fleet, the new destroyers and merchantmen required every gun as soon as it was available for installation.

By October, 1918, some of the contractors were nearing capacity production, and other firms that had begun building guns and mounts for the first time during this war, had started deliveries, so that then, in October, 1918, the Bureau of Ordnance, for the first time since orders had been issued in March, 1917, to arm merchant vessels, had a few guns ahead and felt certain it could keep ahead of the demands. When the armistice was signed on November 11, 1918, there were about 50 guns at the various navy yards on the Atlantic coast ready for installation, and the contractors had reached a stage of production that insured a sufficient output to meet all demands for arming the merchantmen and ships of the Navy, under construction, as they would become ready for service.

On November 11, 1918, there were 1,742 vessels, other than those of the Regular Navy, armed, carrying 4,360 guns, 1,830 of which were of 3-inch or larger caliber. In addition to these vessels, 52 armed vessels, beginning with the *Aztec*, which was sunk on April 1, 1917, had been lost with 132 guns, 104 of which were of 3-inch or larger caliber. Also, there had been delivered to the Allied Governments at war with Germany 345 guns and mounts, 116 of which were of 3-inch or larger caliber.

Altogether, the Bureau of Ordnance had placed in service on merchantmen and delivered to the Allies a total of 4,843 guns, 2,050 of which were of calibers from 3 inch to 6 inch.

When merchantmen were first armed, the allowance of ammunition was 90 rounds per gun, but it was soon determined that 90 rounds per gun was not sufficient and the allowance was increased to 180 rounds per gun. All ships armed previous to the time the new allowance was decided upon, had their allowance doubled and, when necessary, the magazines were rebuilt or new magazines were installed to carry the additional ammunition.

The following table gives the data relative to the guns supplied vessels other than those of the Regular Navy, those furnished the Allies, and includes the 110-foot subchasers, both American and

French; also the 6-pounders sent to arm trawlers and fishermen of Allied Nations, which have not been mentioned before:

AUGUST 11, 1919.

Data relative to guns and armed guards supplied merchant vessels, etc.

	Number.	6-inch 50.	6-inch 45.	6-inch 40.	5-inch 51.	5-inch 50.	5-inch 40.	4.7-inch.	4-inch 50.	4-inch 40.	3-inch 50.	3-inch 50 anti-aircraft.	3-inch 23.	3-inch Davis.	6-pounder.	3-pounder.	1-pounder.	Machine.
MERCHANT VESSELS ARMED BEFORE THE DECLARATION OF WAR, APR. 6, 1917.																		
Armed guards	12	....	6	12	....	....	....	....	8	2	6	....	....	....	2	....	....	....
MERCHANT VESSELS SUPPLIED WITH ARMED GUARDS DURING THE WAR.																		
Merchant vessels	367	43	....	7	48	8	84	2	70	84	289	....	....	....	73	....	....	....
ARMED GUARD VESSELS WHICH HAD THEIR STATUS CHANGED BEFORE NOV. 11, 1918.																		
N. O. T. S.	90	11	....	1	6	1	17	....	11	29	79	....	....	....	11	....	....	....
Transport force	10	2	1	6	1	....	16	....	12	....	2	....	....	....	....	....	....	....
Sunk	34	....	....	....	1	1	5	....	4	16	31	....	....	....	4	....	....	....
Removed	17	....	4	3	1	....	7	2	....	4	14	....	....	....	4	....	....	....
VESSELS ARMED DURING THE WAR ON WHICH GUNS WERE INSTALLED WHEN THE ARMISTICE WAS SIGNED.																		
Transports	44	59	1	30	50	8	16	....	21	....	18	6	....	....	2	2	88	100
N. O. T. S. Navy	77	6	....	....	18	13	9	....	43	12	74	6	....	....	23	2	....	25
N. O. T. S. Army	217	29	....	4	48	1	26	....	33	21	173	....	....	....	43	....	2	2
Armed guards	228	30	1	9	39	6	39	....	51	37	169	....	....	....	56	....	....	....
Foreign vessels	32	....	....	....	....	....	....	8	....	18	16	....	....	....	....	....	....	4
Tenders	8	....	....	2	12	....	16	....	....	....	4	2	....	....	....	....	4	16
Mine planters	10	....	....	....	15	....	....	....	....	....	....	18	....	....	....	....	2	19
Mine sweepers	20	....	....	....	....	....	....	....	....	....	2	36	....	....	....	....	....	40
Yachts and tugs (District service)	70	....	....	....	2	....	....	....	27	2	118	1	....	....	2	2	6	140
Special duty	1	1	....	....	....	....	....	....	....	....	2	....	....	....	....	....	....	2
S. P. boats	626	....	....	....	....	....	....	....	4	2	42	....	....	1	88	203	441	504
110-foot sub chasers	302	....	....	....	....	....	....	....	....	....	....	....	302	....	....	....	....	604
110-foot sub chasers (French)	100	....	....	....	....	....	....	....	....	....	....	....	50	....	100	....	....	....
Eagle boats	7	....	....	....	....	....	....	....	14	....	....	7	....	....	....	....	....	14
Destroyers	126	....	....	....	....	....	....	....	504	....	....	....	168	....	....	....	62	252
Total	1,868	125	2	45	184	28	106	8	697	92	618	76	520	1	314	209	605	1,722

Five thousand three hundred and fifty-two guns with ammunition were supplied to 1,868 vessels, 2,502 of which were of 3 inches or larger caliber and 2,850 of which were smaller than 3 inches. This does not include a number of merchant vessels and section patrol boats that were armed but had had their batteries removed before November 11, 1918, nor does it include 52 vessels which carried a total of 9 6-inch 50-caliber, 7 5-inch 51-caliber, 1 5-inch 50-caliber, 9 5-inch 40-caliber 4 4-inch 50-caliber, 22 4-inch 40-caliber, 49 3-inch 50-caliber, 2 3-inch 23-caliber, 1 3-inch Davis, 2 Y-guns, 6 6-pounders, and 22 machine guns which were sunk during the war. On November 11, 723 Y-guns and 12,647 arbors had been supplied to vessels.

In addition the following material had been supplied to the Allies:

4 14-inch 45-caliber guns.	42 3-inch 23-caliber guns and mounts.
12 6-inch 50-caliber guns and mounts.	149 6-pounder guns and mounts.
10 5-inch 51-caliber guns and mounts.	67 3-pounder guns and mounts.
4 6-inch 30-caliber guns and mounts.	16 Lewis machine guns.
48 4-inch 50-caliber guns and mounts.	17 Y-guns.

Ammunition for all of these guns was supplied when the guns were delivered. Two 5-inch 51-caliber guns and 25 4-inch 50-caliber guns complete with mounts had been shipped to a port on the Atlantic coast for transshipment to Europe for one of the Allied Governments in addition to those shown in the table.

The following list shows the number of vessels that received armed guards during each month of the war:

1917:	Vessels.	1918:	Vessels.
March	12	January	2
April	22	February	6
May	26	March	14
June	38	April	14
July	12	May	22
August	11	June	34
September	22	July	17
October	22	August	23
November	15	September	20
December	11	October	29
		November	7

Ten 3-inch 50-caliber antiaircraft guns and 2 6-inch 50-caliber guns were supplied to stations for repelling aircraft attacks and attacks on aircraft stations.

The Navy as a whole did not engage in major battles at sea during this war, but there were many single ship engagements between ship and submarine which reflect more than credit upon the naval service.

Our troop transports were, as has been noted, among the first ships to be armed. A number of these ships were, in fact, armed before the actual declaration of hostilities, for, on March 13, guns were assigned to the steamships *Manchuria* and *Mongolia*, 14½-knot passenger vessels, the American liners *New York*, *Philadelphia*, *St. Paul*, and *St. Louis*, all fast 19-knot vessels, and the *Kroonland*, another 14-knot passenger steamer.

These vessels were rapidly followed by others, so that, on December 1, 1917, there were, under the direct control of the Navy, 231 armed merchant vessels and troop transports. This of course does not include the hundreds of other vessels armed by the bureau but not retained under the Navy.

This merchant service has given us a number of particularly fine instances of engagements where the spirit and tradition of the naval service have been upheld in a hard and long fought encounter.

It is commonly the idea that a submarine is helpless against a vigorous attack from a surface vessel. On the contrary, the submarine still retains the advantage, because, although more vulnerable, she presents a much smaller target and can always render herself completely immune to gunfire by submerging to sufficient depth. If outmatched, she can disappear, but a merchant vessel, if outmatched in caliber of guns or their range or speed, can only fight on with blind courage. Throughout the war, the Navy armed guards fought under all conditions, sometimes destroying the submarine, sometimes forcing him to submerge and thereby effecting their escape, and sometimes, unhappily, but prolonging to the last a losing battle.

Among some of the more striking instances of such engagements may be mentioned the encounter of the steamship *Campana* with a German submarine in the Mediterranean on August 6, 1917. The *Campana* had sailed without an escort on her return voyage to New York from La Pallice, France, intending to make a stop at Huelva, Spain. At 5.30 a. m., on the morning of August 6, with a smooth sea and a light breeze blowing, three shots, suddenly fired in rapid succession, landed about 100 yards off the starboard bow and 50 yards short. The submarine was soon discovered to be at a range of about 8,000 yards, or a little more than 4½ miles from the vessel. The *Campana* was armed with two 3-inch 50-caliber guns and fire was immediately commenced with the stern gun. From then on, for 4 hours and 10 minutes, shots were exchanged, the range varying but little. The shots of the *Campana* fell short of the submarine about 500 yards, while the submarine's shots were all falling about 200 yards over. At the end of the first hour the submarine closed to about 7,300 yards and four of the *Campana* shots were seen to hit. The submarine immediately dropped back out of range and continued her firing.

Hour after hour the fight continued. The gun pointers stayed at their guns until their eyes became swollen and their ears bled. After about two hours the submarine got the range and her shots fell close to the stern. Four hits were made, one of which caused a fire. The fire was extinguished by the ship's force. At the end of three hours of fighting the captain wished to stop and abandon ship, but the Navy gunner in charge would not allow it. After another hour and 10 minutes of fighting, with only 10 rounds of ammunition left, the "abandon ship" signal was hoisted.

The submarine stopped and, after looting the ship, took the captain of the armed guard and four of the Navy seamen prisoners. The prisoners were taken to Germany and placed in a prison camp, where they remained, despite frequent attempts to escape, until after

the signing of the armistice, when they were released and returned to the United States.

Another encounter with a happier ending was that of the steamship *Navajo*, which encountered a submarine 110 miles off Portsmouth, England, on the afternoon of July 5, 1917. The ship was sailing from New York for Havre, and shortly after 9 o'clock on the morning of that day sighted a submarine firing on a British sailing vessel. Although the *Navajo* made every effort to escape, at 2.55 p. m. the submarine was sighted distant 2,500 yards, and heading for the *Navajo*. Immediately after being sighted, the submarine opened fire, which the ship, of course, returned.

The shots of the submarine all fell close, but by careful maneuvering of the ship, but one hit was sustained under the port counter, which was not serious. The *Navajo* fired 27 shots; the twenty-sixth shot hit just forward of the gun of the submarine and a cloud of flame broke from the hatches. The submarine's gun crew left the gun and ran aft, and the submarine sank, bow first, stern high out of the water and propellers revolving.

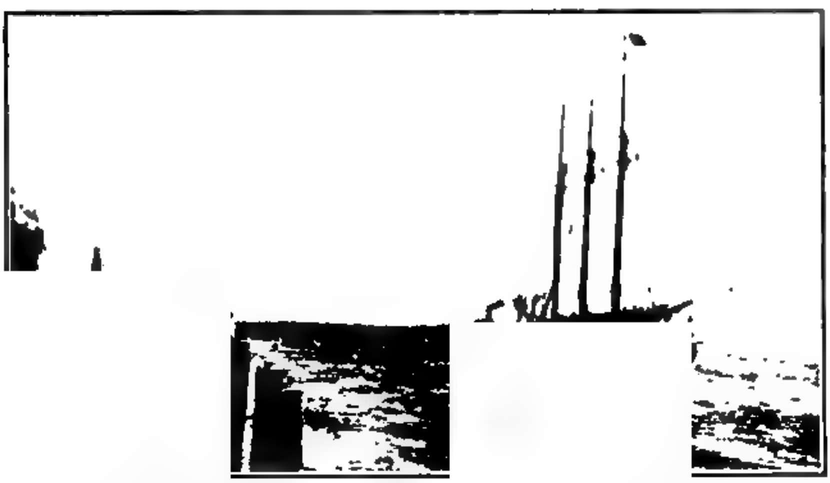
The American liners *St. Louis*, *St. Paul*, *New York*, and *Philadelphia* seemed to be especially desired by submarines as victims. Many times submarines were sighted, which evidently were lying in wait for these fast vessels. On one occasion, a submarine periscope was sighted distant but a few hundred yards, and a torpedo was sighted just as it left the tube, aimed at the *Philadelphia*. Quick maneuvering of the helm caused the torpedo to miss. The *St. Louis*, on another occasion, sighted a periscope on the port beam, but by quick and timely fire drove off the submarine. And on another occasion, a torpedo was sighted distant 200 yards. The periscope of the submarine was then seen, but the ship was making a heavy smoke and managed to lose it. Again a submarine was sighted distant 3 miles from the *St. Louis*, which opened fire with both her guns as soon as sighted. For 25 minutes there was a running fight between the submarine and the liner. The *St. Louis* gradually drew away, on account of her superior speed.

The story of the rescue of the steamship *J. L. Luckenbach* on the morning of October 19, 1917, has been told a number of times, but will bear repetition. The *Luckenbach* encountered a submarine at 8 a. m., on October 17, while bound from New York for St. Nazaire. The submarine was sighted disguised as a sailing vessel, and immediately opened fire. Although the *Luckenbach* was armed with two 4-inch guns she was outranged by the submarine. The *Luckenbach's* fire was so accurate that the submarine was obliged to remain out of her range, which undoubtedly prevented the *Luckenbach* from being hit seriously. For four hours the battle was continued, while

TORPEDO WAKE, SMOOTH SEA

U. S. SUBMARINE SUBMERGING AT HIGH SPEED

FORWARD GUN AND LOADING PLATFORM ON BOARD THE STEAMSHIP E. L. DRAKE.



THREE-MASTED SCHOONER GLYNN ARMED WITH TWO 6-POUNDER SEMIAUTOMATIC GUNS MANNED BY NAVY CREWS.

The naval officer in command of the armed guard was forced to take command of the vessel because of the pro-German actions of the merchant skipper, whom he demoted to seaman. The Glynn sailed from Brunswick, Ga., April, 1917, arrived Gibraltar, May 17, sailed from Gibraltar, June 7, and arrived Genoa, Italy, on July 7. On June 14, in an encounter with a German submarine, mounting two 4.7 guns, the schooner received 43 holes in hull and rigging from shell fragments. The submarine is thought to have been sunk, and this is probably correct, as there were no more submarine activities in the vicinity of Gibraltar for a month following this action.

the *Luckenbach's* wireless operator kept sending out S. O. S. appeals for help. The wireless appeal was picked up by the U. S. S. *Nicholson*, at a point 80 miles away. Signaling to the *Luckenbach* to hold out, the *Nicholson* put on every ounce of steam and made for the spot where the encounter was taking place. It was nearly noon when the *Nicholson* approached the *Luckenbach* and could see the flashes of gunfire. Setting her forward gun at maximum range, the *Nicholson* fired three shots at the point where the submarine's flashes were seen, which were sufficient to drive the submarine off and force her to submerge.

The *Nicholson* came alongside the *Luckenbach* and rendered such assistance as was necessary. The ship was not able to get under way in time to permit her joining the convoy, to which the *Nicholson* was an escort, and she arrived safely in port after her convoy.

During the encounter with the submarine, the *Luckenbach* fired a total of 202 rounds. Not a misfire was reported throughout the engagement, and the guns worked excellently. The after gun of the *Luckenbach* was put out of commission toward the end of the engagement by a lucky shot from the submarine, but fire was continued with the forward gun effectively. The quality of ammunition supplied is all the more noticeable, because just previous to sailing the magazines of the *Luckenbach* were accidentally flooded, and the ammunition was thoroughly wet. Insufficient time remained to change it, however, and the ship sailed with the wet ammunition. The careful way in which it had been packed prevented it from being damaged by the water, and in action it functioned perfectly.

Many other instances of similar encounters with submarines have been reported. The steamship *Moreni*, an oil tanker of 8,500 tons displacement, encountered a supersubmarine 17 miles southwest of Tadarca Island, Spain, on the morning of June 12, 1917. The guns of the *Moreni* were outranged, but the Navy armed guard fought gallantly. After a half hour of hot action the ship was hit in a gasoline tank and a fire started. While the fire was spreading over the ship the steering gear was shot away and the ship commenced to turn in a circle. After having fired 150 shots at the submarine the men took to their boats and abandoned the ship, which was later sunk by gunfire from the submarine.

Many instances are recorded where prompt and effective gunfire from armed merchantmen had succeeded in effectively stopping a submarine attack and saving the ship. Indeed, when the periscope of a submarine was sighted before the submarine had a chance to launch a destructive torpedo or where the guns of the submarine did not vastly outrange the guns of the merchant vessel, the ship in almost all cases escaped. Thus the *Dakotan*, on September 6, 1917,

drove off a submarine, as did the steamship *Gold Shell*, on July 10, 1917.

An oil tanker, the *Albert Watts*, had a particularly thrilling encounter with two submarines when in convoy with the steamship *Westoil* on the morning of November 28, 1917. At 9 a. m. two periscopes were sighted, one on the starboard bow and the other on the starboard quarter. The *Westoil* and the *Albert Watts* commenced firing with both guns at the periscopes, which had appeared at short range—300 yards. For over four hours a running fire was kept up with the submarines. Every few minutes the periscopes would bob up, apparently in an endeavor to get into position for launching a torpedo, the ships would open fire and the periscopes would disappear. At about 10.30 the *Watts* struck a mine which, although it damaged her, did not cause her to sink, and the convoy arrived safely in port on the afternoon of the 28th, the *Albert Watts* arriving the same night.

The *Westoil* had another similar encounter in the Mediterranean on the morning of March 12, 1918. A submarine appeared astern and opened gunfire. After a running fight with the submarine, the undersea boat was forced to give up, although her guns were apparently heavier than those of the *Westoil.* The commander of the armed guard of the *Westoil* was a 12-inch gun pointer from one of our big battleships, who, in five years, had never made a miss in short range battle practice.

Our troop transports, too, were not immune from the attacks of submarines, although vessels designed to carry troops were given a much heavier armament than those for merchant service only. Although there were a number of engagements between troop transports and submarines, when these engagements took place on the trip from the United States to Europe, the escorts of the troop transports in all cases took up the battle with the submarine, so that the troop transports themselves looked mainly to their own safety. On the return trip, however, when the ships were not carrying troops it was found that, in most cases, the submarines did not care to risk a battle with a heavily armed transport, even should the ship wish to give battle.

No hard and fast rule was laid down by the commander of the cruiser and transport force, as to the procedure of returning troopships in the event of submarine gun attack. This was done purposely, in order that the captains of transports might use their discretion as to whether or not it was advisable for the ships to give battle. It would, of course, be very inadvisable for a transport such as the *Leviathan*, to give battle to a submarine, for the possible loss could, in no case, be equal to the possible gain, and even though the *Leviathan* carried a battery of eight 6-inch guns, there would always

remain the chance of her loss, should she stop to offer battle to a German submarine. On the other hand, smaller transports, of less military value, might well risk battle with the chance of destroying a super-submarine. In the words of the commander of the cruiser and transport service, the procedure of the Navy transports was one "that would keep the submarine in doubt as to the action of any transport he might meet, but still one that would leave no doubt in his mind that the United States transports are men of war, and dangerous to close with in a gun engagement."

Toward the close of the war, the troop transports were being equipped by the Bureau of Ordnance with an 8-inch howitzer, adapted to a 4-inch gun mount, which was capable of throwing a high explosive shell weighing about 280 pounds to a maximum distance of 2,900 yards.

It is difficult to measure precisely the extent of gain in safety obtained by arming our merchant marine. For the period of April 1 to December 1, 1917, during which time the arming of our merchant marine was its chief protection, owing to the fact that the convoy system was as yet in its comparative infancy, and the organization of the Allies antisubmarine defense was still unperfected, 80 per cent of the sinkings of United States merchant vessels were caused by unseen torpedoes or torpedoes seen too late to save the ship. Where the submarine had been sighted before it had a chance to launch a well-aimed torpedo, the guns and armed guards of the vessels proved all very effective weapons against it. Excluding sinkings by unseen torpedoes, only 9.1 per cent of attacks by gunfire, or otherwise, on merchant vessels were successful.

CHAPTER IV.

GUNS, MOUNTS, AND SMALL ARMS.

As has been explained in previous chapters, the principal part played by the United States Navy in the war was its share in the defeat of the submarine. The first measures for the accomplishment of this purpose were, of course, defensive ones—arming of merchant vessels, and instituting the convoy system. By these means the sinkings by submarines were reduced from a dangerous point to one which, while annoying, was by no means critical. Later the use of depth charges and mines made offensive methods possible, and the submarine was attacked and driven from the seas.

As has been previously explained under "Arming Vessels," the bureau's share in this diminution of submarine losses was the provision of armament and ammunition for naval vessels, large and small, and for merchantmen. In this chapter will be given in some detail the activities of the bureau in procuring the guns, gun mounts, and small arms for these vessels.

For purposes of administration, guns and gun mounts are handled in the bureau by different sections, but since the war-time activities were such that guns of 6-inch caliber and under were the ones provided, the war history of the two bureau sections may well be considered together. The war personnel of these two sections who cooperated and accomplished the production necessary will be found in Appendix II of this publication.

Previous to the war, the bureau had assembled a number of reserve batteries at various navy yards for use in arming the American merchant marine in case of war. These batteries consisted of 6-inch guns and below, with their mounts, and were assigned with due regard to the number of guns available and to the character of the ships to be armed. In addition to the reserve batteries, there were on hand a certain number of spares and replacements for all calibers of guns in service. Some of these were an old type, such as the 13-inch 35-caliber and the 8-inch 35-caliber guns, and some were in use as station guns at the naval proving grounds.

Beginning with the 14-inch 45-caliber guns, which was the largest caliber mounted on ships then in commission, the following table

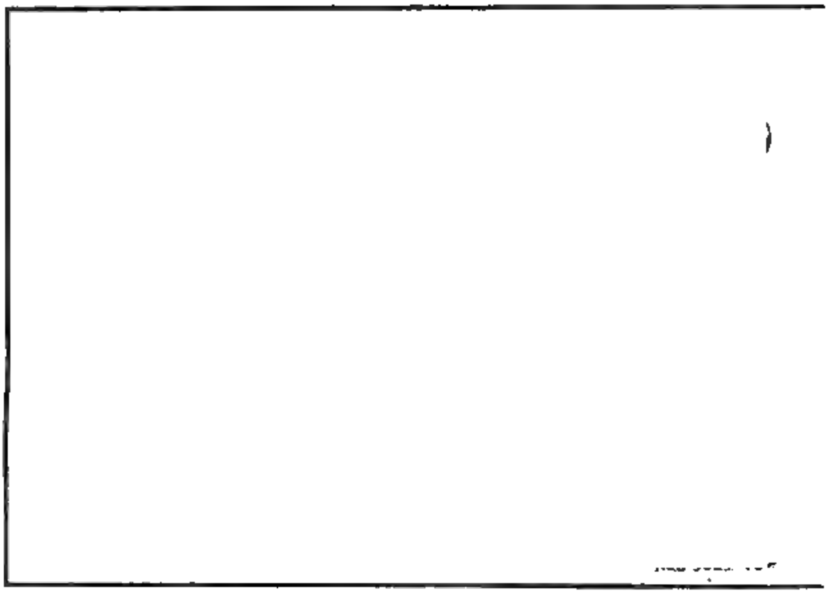
shows the guns ashore that were available as replacements, spares, and reserve batteries upon severance of diplomatic relations with Germany:

Caliber of gun.	Replacements.	Spares.	Reserve batteries.
14-inch 45-caliber	16	1	
13-inch 35-caliber	4		
12-inch 50-caliber	6	7	
12-inch 45-caliber	20	3	
12-inch 40-caliber	8		
12-inch 35-caliber	2	5	
10-inch 40-caliber	4	5	
10-inch 30-caliber	4	8	
8-inch 45-caliber	29	9	
8-inch 35-caliber	12	8	
7-inch 45-caliber	18	5	
6-inch 50-caliber (bag)	50		18
6-inch 45-caliber			6
6-inch 40-caliber			24
5-inch 51-caliber	35		
5-inch 50-caliber	30	1	
5-inch 40-caliber			84
4-inch 50-caliber (all marks)			56
4-inch 40-caliber			90
3-inch 50-caliber			84
3-inch 50-caliber, Mk. X. A. A	8		
3-inch 23-caliber sub	3		
6-pounder			136
3-pounder			180

In addition to the guns as shown in the foregoing table, there were four 10-inch 40-caliber guns and sixteen 6-inch 50-caliber guns on the *Memphis* and fourteen 6-inch 50-caliber guns on the *Milwaukee*, both of which vessels had been wrecked. The salvage of these guns with their mounts was undertaken and completed in the summer of 1917.

Prior to the war gun forgings had been furnished by four companies, namely, Bethlehem Steel Co., Crucible Steel Co., Midvale Steel Co., and Erie Forge Co. Gun manufacture by outside firms had likewise been limited to three companies, namely, Bethlehem Steel Co., Midvale Steel Co., and American & British Manufacturing Co. The Bethlehem Steel Co. and the Watervliet Arsenal had some limited experience in building naval broadside gun mounts. The demands of the Navy for both guns and mounts had, however, been chiefly met by the Naval Gun Factory at the navy yard, Washington, D. C. This was particularly true of mounts.

Even before the United States entered the war it was decided to arm merchantmen as a result of the promulgation by Germany of her unrestricted submarine policy. Numerous demands were at once made for broadside guns, machine guns, rifles, and pistols, which quickly absorbed all the reserve batteries and the reserve supply of small-arms material. Immediately after the declaration of war the demands became so great and so insistent that it became necessary to remove part of the broadside batteries from battleships. The demand at this time was chiefly for guns from



3-INCH 23-CALIBER GUN.

4-INCH GUN WITH SPRAY SHIELD ON U. S. S. MANLEY.

3-INCH ANTIAIRCRAFT GUN AND MOUNT.

1-pounder to 3-inch caliber for arming submarine chasers, launches, and patrol boats, and the first contracts for both guns and mounts were of this class. It soon became apparent, however, that guns of the larger calibers would be required, because of the larger caliber of guns carried by enemy submarines, and subsequent contracts were for 4-inch and 5-inch guns and mounts. The mounts had been modified to give a long recoil in order to bring less strain on the structure of the vessels which were to carry them.

A comprehensive estimate of the situation was made as soon as possible after the declaration of war, with a view to determining the number of guns and mounts that would be required to take care of the contemplated activities of the shipping board, as well as the needs of naval vessels building and contemplated. This estimate showed that about 6,000 guns and mounts of 3, 4, and 5 inch calibers would be needed. Contracts were placed on this basis in the early part of 1917, but as the building programs of both the Navy and the Shipping Board expanded additional contracts were placed to care for them.

In the placing of these contracts the assistance of the advisory committee on plants and munitions of the War Industries Board, of which Mr. Samuel M. Vauclain was chairman, was invaluable to the bureau. Lieut. Commander N. W. Pickering, United States Navy, had duty as representative of the bureau with the Army and Navy artillery committee, and considerable time and effort was spent in developing new industries and arriving at settlements with the Army in regard to capacities to be retained wholly for naval purposes. Time being a feature of great importance, it was necessary to give the utmost attention to all new projects.

The requirements having been determined, it then became necessary to enlist the cooperation of all firms who could be induced to undertake the manufacture of guns and mounts and to enter into contracts with them. This latter was not a matter of letting contracts to eager aspirants, but rather one where the initiative must come from the officers of the bureau not only in the initial placing of the contract but in every stage of subsequent production. It was a matter of education of the contractors, and, even further, the closest supervision over the subcontractors who furnished the metal and supplies to primary contractors. Particularly was this true of metal for gun forgings. Approximately 34,000 tons of alloy steel suitable for guns was ordered from the United States Steel Corporation, and, while the corporation did everything in its power to meet Navy requirements, it still needed guiding in the right direction.

Another striking instance of the necessity for bureau supervision over manufacture incidental to its requirements was furnished by the machine-tool industry. The large number of new plants started

by both the Army and Navy for the production of all classes of war material caused a keen competition in this industry, and the bureau found it necessary to keep a representative at the large machine-tool plants to insure prompt deliveries to plants under Navy supervision in advance of deliveries to other projects of less importance.

The activities of the Naval Gun Factory in the production of guns and mounts are more fully described in a later chapter on "Naval Ordnance Stations." However, it is here pertinent to state that the Naval Gun Factory was pushed to the utmost and operated at full capacity throughout the war. Over 300 guns and mounts of various calibers were made by the gun factory, and every gun and mount of whatever manufacture was passed through the gun factory for examination and preparation for service, both before and after its proof firing at the naval proving ground.

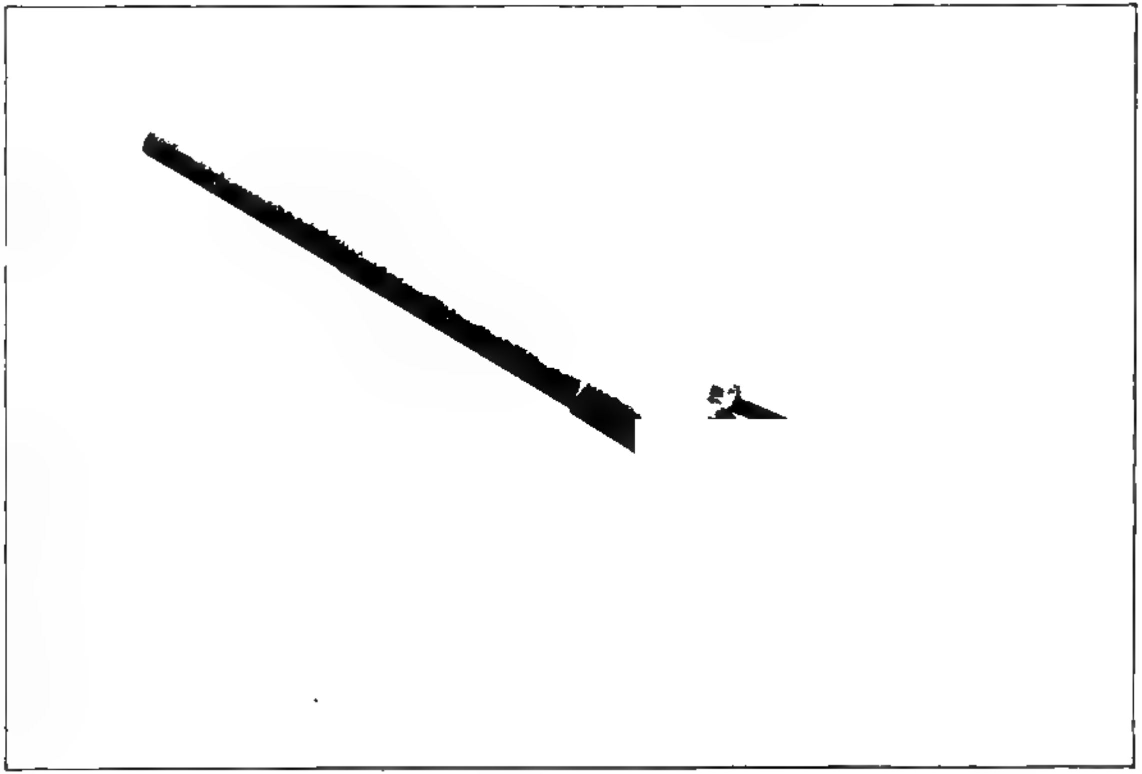
Coincident with the need for guns, mounts, and small arms with which to arm merchantmen, there arose a tremendous demand for target-practice material and training devices of all kinds to keep the training squadrons supplied. During the war, target practices for guns of 6-inch caliber and below were almost daily occurrences, as training of the new men in the service was one of the most important problems of the war, and one that was met so fully by the Atlantic Fleet under Admiral H. T. Mayo. As soon as the guns' crews were properly prepared, they were put through a target practice and held ready for transfer, to supply the ever-present demands for armed guards for our merchantmen, transports, and liners. The training camps, armed-guard camps, and rifle ranges, which sprang up almost overnight, all demanded ordnance material and equipment, in addition to broadside guns, to continue the incessant practices and drills, which all realized must be gone through with if the Navy was to do its part.

GUN CONTRACTS.

The manufacture of naval guns was so radical a departure from any ordinary commercial manufacture, that a reorganization and reequipping were necessary by all companies willing to undertake it. In most cases new plants had to be built or extensions added to buildings already existing. In all cases the companies had to be taught gun forging and gun manufacture.

Due to the large amount of money necessary to start new projects, very few companies were able to finance themselves. Furthermore, the lack of experience of many of these companies prevented them from being able to determine in advance the probable cost of production. Therefore, it was necessary for them either to take a contract at a figure which was prohibitive, or to take the contract on a cost-plus percentage basis. This latter method was not ap-

VIEW OF 8-INCH VICKERS TYPE HOWITZER BUILT FOR U. S. MARINE CORPS.



A 6-INCH 40-CALIBER GUN MOUNT AT 30° ELEVATION.

This mount originally had a maximum of but 15° elevation and was the first mount modified at the New York Yard.

58-2

proved by the bureau, as it had no tendency to keep cost down; for instance, the greater the cost, the greater the profit. Therefore, all gun contracts were drawn on a basis that the Government would pay the cost, which was clearly defined as regards special features, plus a fixed profit of so much per gun or per pound of forging, which was to be paid the manufacturer provided the unit of work was completed satisfactorily. A manufacturer received no profit for any spoiled or replaced material. Furthermore, these contracts, almost without exception, contained a clause, which provided for the disposition of the plant upon completion of the contract. The manufacturers agreed to bid a certain percentage of the cost of the plant and this bid would be considered by the department in comparison with other bids, or with its own requirements.

Below is given in tabular form a statement of the date on which contract was entered into with each company, together with the date when work was actually begun, and the date of delivery of the first finished product:

Manufacturer.	Material.	Date of contract.	Date work commenced.	Date of first delivery.	Remarks.
Tioga Steel & Iron Co.	3-inch and 4-inch gun forgings.	Aug. 4, 1917	Mar. 19, 1918	May 29, 1918	Built new plant.
Inland Ordnance Co.	.....do............	July 12, 1917	Jan. 24, 1918	Mar. 31, 1918	Built new extension.
Alloy Steel Forging Co.	3-inch and 6-pounder gun forgings.	Sept. 14, 1917	....	June 20, 1918	Commandeered Dec. 4, 1917. Built new plant.
Erie Forge & Steel Co.	4-inch and 5-inch gun forgings.	Oct. 24, 1917	May 17, 1918	Aug. 6, 1918	Built new plant.
Root & Van Dervoort Engineering Co.	4-inch guns......	May 25, 1917	Nov. 10, 1917	Apr. 3, 1918	Do.
	1-pounder guns....	Dec. 3, 1917	Apr. 4, 1918	Aug. 15, 1918	
American Radiator Co.	4-inch guns.......	June 7, 1917	Feb. 13, 1918	Aug. 21, 1918	Do.
General Ordnance Co.	3-inch guns........	May 16, 1917	Nov. 17, 1917	Apr. 20, 1918	Work started in advance of contract.
	Y guns............	Dec. 8, 1917	Nov. 24, 1917	Dec. 10, 1917	
Poole Engineering & Machine Co.	3-inch guns.......	Apr. 6, 1917	Apr. 6, 1917	Sept. 3, 1917	Built new plant.
	4-inch guns.......	Aug. 29, 1917	May 15, 1918	Jan. 29, 1919	
Four Lakes Ordnance Co.	5-inch guns.......	Oct. 11, 1917	Mar. 1, 1918	Sept. 28, 1918	Do.
Defiance Machine Works.	3-inch antiaircraft guns.	July 30, 1917	Feb. 23, 1918	Aug. 12, 1918	Do.
Driggs Ordnance Co.	3-inch guns.......	Apr. 12, 1917	....	Feb. 26, 1918	Contracts canceled.
	1-pounder guns....	Apr. 3, 1917		Oct. 16, 1917	
Savage Arms Corp..	3-inch guns.......	Apr. 17, 1917	June 17, 1917	Apr. 12, 1918	
	6-pounder guns....	.....do.......	June 3, 1917	Mar. 2, 1918	
Liberty Ordnance Co., ex Bridgeport Projectile Co.	5-inch guns.......	Nov. 13, 1916	....	July 17, 1918	Commandeered by the War Department.

In spite of many unforeseen difficulties, most of these plants did excellent work. A few of them, for one reason or another, did not measure up to expectations. As regards commendable zeal and performance, it is believed special mention should be made of the following:

Tioga Steel & Iron Co.: This plant was completely built and equipped, without a nucleus of material or trained personnel from

which to develop its organization, and was able to do very satisfactory work.

Inland Ordnance Co.: This company, a subsidiary of the McMyler Interstate Corporation, had a good organization to draw on, with plenty of engineering facilities, and was able to make prompt deliveries of gun forgings.

Root & Van Dervoort Engineering Co.: An efficient organization was developed in a very short time. With no previous experience in gun manufacture, and with a shop force almost half of which consisted of women with no mechanical training, the Root & Van Dervoort Engineering Co. delivered the first gun manufactured in a plant built since the beginning of the war. This gun, a 4-inch of the latest type, was finished in a little less than five months from the date of commencing productive work, or 10 months from date of contract. At the time the armistice was signed, the company had reached a production of 90 4-inch guns per month.

Poole Engineering & Machine Co.:

This company manufactured a large number of 3-inch boat guns, in a plant that had previously worked on foreign orders. Notwithstanding the war conditions and the probable difficulty to be encountered in the production of a new type of gun, the bureau felt that the 110-foot chasers ought to carry a gun of heavier caliber than 2.4-inch, or the 6-pounder naval gun, the heaviest gun permissible, if the existing Navy types only were adhered to. A 3-inch caliber was wanted. The problem and the haste for solution were solved by the 3-inch 23-caliber gun designed by this company as the result of a study lasting but a few days. The gun proved well adapted for this purpose, and production was accomplished in sufficent quantities to meet the demands of vessels. The first gun was delivered seven months from date of contract.

American Radiator Co.:

Here a very good organization was built up, which had placed the plant on a production basis of approximately 60 4-inch guns per month, at the time the armistice was signed. In spite of the labor conditions existing in the East, the labor turn-over in this company was remarkably small, averaging about 2 per cent.

Four Lakes Ordnance Co.:

In October, 1917, the Steinle Turret Machine Co., of Madison, Wis., started a contract for 5-inch guns. The energy and ability displayed by the president, Mr. Steinle, is worthy of special record. The plant was erected in 54 days, and Mr. Steinle personally followed the production of machine tools for this plant and, at a considerable personal sacrifice, endeavored to obtain early deliveries. The lateness of beginning work at this plant prevents a fair comparison of its production with that of other plants.

16-INCH GUN ON TRANSPORTING CRANE AT NAVAL PROVING GROUND.

8-INCH HOWITZER, WHICH THROWS A HIGH-EXPLOSIVE SHELL WEIGHING 280 POUNDS A DISTANCE OF 2,900 YARDS.

General Ordnance Co.:

This plant greatly assisted the bureau in developing the Y gun, and was able to produce it in quantities of three or four each day, after a successful gun was built.

On the other hand, the Liberty Ordnance Co.—previously known as the Bridgeport Projectile Co.—fell down woefully in their deliveries. Contract for 146 5-inch 51-caliber, Mark VIII, guns was placed with this company November 13, 1916, at a fixed price. This contract was changed to a cost plus fixed profit contract on September 27, 1917. Work on this contract was exceedingly slow, and on January 7, 1918, the Army commandeered the plant and put the American Can Co. in to run it. Under this management, the first gun on the contract was delivered July 17, 1918, or over 20 months after the contract was made. The uncompleted part of this contract was canceled in November, 1918, after only 19 guns had been delivered.

As the days drew along with the need for gun forgings growing greater the conduct of affairs at the Alloy Steel Forging Co. at Pittsburgh caused much apprehension and concern on the part of the bureau. Forgings were not being delivered and the Navy needed them. Through the cooperation and courtesy of the Carnegie Steel Co. arrangements were made by the bureau to operate the plant placing as its superintendent, Mr. Thomas Higgins, a man well known to be capable of quickly turning out forgings. On the eve of the day set for the Navy to take over the plant, the arrangements miscarried and no superintendent was available. The chief of the bureau in this dilemma called upon Mr. Samuel M. Vauclain—who never failed it throughout the war in many emergencies—for assistance. He set to work upon the proper officials of the Steel Corporation with the result that the superintendent originally selected was on the job at the time set and the production at this plant never again caused any worry to the bureau.

Probably as good a way as any to summarize the activities of the gun section during the war is to list the number of guns of all calibers finished and delivered between April 6, 1917, and November 11, 1918. The list is as follows:

16-inch	1
14-inch	29
6-inch	11
Y guns	947
5-inch	195
4-inch	615
3-inch 50-caliber antiaircraft	823
3-inch 50-caliber	376
3-inch 23-caliber	532
3-inch submarine	38
3-inch Davis nonrecoil	150
6-pounder	78
1-pounder	183
Total	3,478

In addition to providing guns and mounts for its own needs the Bureau of Ordnance furnished some 147 guns from 3-inch to 14-inch in caliber to the Allies.

Among these were four of the latest type 14-inch 45-caliber guns, which were shipped to the British Admiralty between August 18, 1917, and September 8, 1917, for use on the shallow draft monitors bombarding the Belgian coast.

Teh of the latest type of 5-inch 51-caliber guns were delivered to the Italian Government, September, 1917. These guns were mounted on barges and did effective work on the Piave, during the critical period on the Italian front.

Besides these, the bureau was able to turn over to the Army between January, 1918, and August, 1918, 119 guns of 6-inch to 14-inch caliber, exclusive of the Naval Railway Battery in France.

GUN-MOUNT CONTRACTS.

The manufacture of broadside gun mounts presented a problem to the manufacturer just entering the field somewhat different from that described for guns, in that no special machinery other than gauges, jigs, fixtures, and patterns were necessary. There was, therefore, no necessity for the bureau to finance any plant extensions, and contracts for gun mounts were placed to meet all requirements at fixed prices.

The bureau was assisted in its efforts to supply gun mounts by such firms as the Linderman Steel & Machine Co., of Muskegon, Mich.; the Mead-Morrison Manufacturing Co., of Boston, Mass.; the Ohmer Fare Register Co., of Dayton, Ohio; the Miehle Printing Press and Manufacturing Co., of Chicago, Ill.; the Goss Printing Press Co., of Chicago, Ill.; the R. Hoe & Co., of New York City; the Russell Motor Car Co., of Buffalo, N. Y.; the Poole Engineering & Machine Co., of Baltimore, Md.; and the American Steel Products Co. in its Brantford, Ontario, plant. These well known and substantial companies in each case brought to bear on the problem of gun-mount production a trained and efficient engineering staff, the members of which threw themselves into the work in a manner worthy of the cause they were serving. The assistance given them by Commanders H. Delano and G. M. Courts of the Naval Gun Factory was of inestimable value.

Their representatives went over the drawings with officials of the gun factory and studied the methods in use at that plant. It was realized that standards must be set for this work, besides the plans and drawings, and those of the gun factory were adopted. To the cooperation between the gun-mount manufacturers and the gun factory was largely due the great success attained in the quantity production of gun mounts. Often representatives of a manufacturer would spend weeks at a time at the gun factory, studying the methods in use, while on the other hand, many leading men and special

GUN TUBE READY FOR QUENCHING.

63-1

FORGING A GUN JACKET IN A 2,500-TON PRESS.

62-2

mechanics of the gun factory took temporary employment with these companies, for the single purpose of speeding up production.

Other companies took contracts for this work, some with indifferent success, but the ones mentioned above attacked the problem in a manner that made only success possible.

All contractors had numerous subcontracts for parts or supplies. Great difficulty was at first experienced by the foundrymen of the country in the production of steel castings for gun mounts. The Superior Steel Castings Co., of Benton Harbor, Mich., was the first foundry to attain success in this work, and for some months this foundry was almost the only reliable source of supply for any and all types of naval broadside gun-mount castings. For several months the total capacity of the company was allocated by the bureau to the gun-mount contracts most urgently in need of castings. This company deserves special commendation for the whole-hearted manner in which it volunteered advice to less successful competitors until other foundries had been brought to a satisfactory production basis.

Again, contractors found the manufacture of sights especially difficult and at first regarded the allowed tolerances as too severe. This resulted in delaying the delivery of completed mounts because, while the mounts were ready, there were no sights to go with them. Inasmuch as the effect of this condition was an accumulative delay in the delivery of mounts, the bureau placed additional sight contracts with the Mead Morrison Manufacturing Co. for 4-inch and with the Illinois Tool Works for 5-inch sights. In the meantime attention was focused on sight manufacture and every available resource was examined for a solution of the predicament at hand and to prevent similar delays in the later deliveries. A great many of the sights on the early deliveries were absolutely unsatisfactory for issue to service, and it was necessary for the gun factory to rebuild them. This referred particularly to sights for the 4-inch mount. The speed made by the gun factory in rebuilding these sights released a large number of 4-inch mounts, much needed for arming destroyers and transports. At another time it was possible for the bureau to assemble some 3-inch antiaircraft sights built by one contractor, who was behind in mount manufacture, with the mounts of another contractor who was behind in sight manufacture. This released some 50 antiaircraft mounts at a time when they were most urgently needed.

The accomplishments of the principal gun mount contractors is summarized as follows:

The Linderman Steel & Machinery Co. had total contracts for 1,400 4-inch and 450 5-inch broadside gun mounts and 42 3-inch submarine mounts. The company manufactured the mounts in its plant at Muskegon, Mich., and procured sights from subcontractors. The

work at Muskegon was excellent. The sight work, however, was not so good and it was necessary for the gun factory to rebuild many of the first sights delivered. The first 4-inch mount deliveries on war contracts were made by this company. To properly appreciate the accomplishments of this company it is necessary to first visualize its status at the beginning of the war. It was a small concern, manufacturing woodworking machinery, which previous to our entry into the war had had some experience in the manufacture of shells for the British Government. With our entry into the war, contracts were taken one at a time until a total, as indicated above, had been reached. In the meantime the company was equipping itself for the carrying out of these contracts. This involved a complete and costly new outfit of machinery, jigs, and fixtures, and a radical expansion in its building equipment and organization. The soundness of its policies is indicated by the results which it achieved.

The Mead Morrison Manufacturing Co. had total contracts amounting to 1,000 4-inch mounts. At the beginning of the war this company was engaged in the building of coal-handling machinery. It had had some experience in the manufacture of shells. With the taking on of gun-mount work it was necessary for it to revamp its organization and equip itself for doing work which was entirely different from its usual line. Before the signing of the armistice this company had attained a production of approximately 75 mounts per month.

The Ohmer Fare Register Co. had contracts totaling 1,000 3-inch broadside mounts and 1,065 4-inch mounts. This company also found a radical expansion necessary in its organization and equipment, in order to meet its delivery dates. It had this advantage, however, its organization had been schooled to working within close tolerances, and this advantage was reflected in its output. The 3-inch contract was the first one taken by this company and its performance under this contract resulted in a sustained production and delivery of satisfactory 3-inch mounts which gave extensive service during the war. The difficulties under this contract were increased by the fact that the design was altered, after quantity production had begun, to provide for an increase in elevation from 15° to 30°. No 4-inch mounts were delivered during the war, but the company was ready for quantity production of 4-inch mounts when the armistice was signed.

The Miehle Printing Press & Manufacturing Co. had total contracts for 375 5-inch mounts. This company, with its splendid organization and equipment and with the addition of a number of machine tools was enabled to begin turning out mounts on schedule time. No one of the bureau's contracts gave less trouble than this one and the material delivered was of a high standard of workmanship. It was

A LARGE BILLET BEING EXPANDED UNDER A 10,000-TON PRESS.

64-1

ASSEMBLING AND TESTING SHOP OF THE LINDERMAN STEEL & MACHINE CO., MUSKEGON, MICH., SHOWING FINISHED PARTS AND MOUNTS IN PROCESS OF ERECTION.

always evident that this company intended to produce in the manner desired by the bureau and this it did in a spirit of warm loyalty and cooperation.

The Goss Printing Press Co., had total contracts for two hundred 4-inch and one hundred 6-inch mounts. Here again the equipment and organization were such as to insure deliveries of satisfactory materials. At one time during the life of the 4-inch contract this company was having trouble in the manufacture of sights. An appeal was made to the bureau for assistance, and it was possible to arrange for Mr. Runback of the gun factory to take temporary employment with the company. Through his efforts and the naturally effective organization of this company the sight troubles were soon eliminated. The 6-inch contract was given to this company under rather unusual conditions. There were at the gun factory about fifty 6-inch 50-caliber broadside guns which were being held in reserve in accordance with bureau policy to replace guns in service when it became necessary to reline them. There were, however, no mounts for these guns, and the guns were badly needed in service for the arming of transports. It was therefore decided to place a contract for one hundred 6-inch 53-caliber mounts which would be needed later on for the broadside batteries of battle cruisers and for 50 additional slides which could be used to mount the 6-inch 50-caliber guns in the 6-inch 53-caliber mount. This contract after competitive bids was awarded to the Goss Printing Press Co.

R. Hoe & Co. of New York had contracts for four hundred 4-inch and two hundred and fifty 3-inch antiaircraft mounts. This company had excellent facilities and turned out an excellent 4-inch mount. No deliveries were made on the 3-inch mount contract before the termination of hostilities.

The Russell Motor Car Co. had contracts totaling six hundred and fifty 3-inch antiaircraft mounts. This Canadian company organized a branch in Buffalo especially for the purpose of taking war contracts. The mounts produced by this company were very satisfactory, but early deliveries were not made because of the delay in manufacturing sights. At this time there was a lively demand for antiaircraft mounts of this type, guns were available, mounts were available but with no sights. The bureau at about this time located 50 sights of this type which the Detrick & Harvey Co. were holding for delivery to the Bethlehem Steel Co., whose mounts were not yet ready for delivery. By assembling these 50 sights with 50 mounts from the Russell Motor Car Co., the bureau was enabled to release fifty 3-inch antiaircraft outfits which were badly needed.

The Poole Engineering & Machine Co. had contracts totaling eight hundred 3-inch 23-caliber guns and mounts made up in accordance with

their new design. In March, 1918, after a few mounts had been accepted, deliveries had practically ceased because of the inability of the company to obtain suitable steel carriage castings of a new design. In the meantime some 40 or 50 subchasers at New London were waiting for the installation of guns of this type previous to sailing for the war zone where they were badly needed. The company was encouraged to experiment with a bronze carriage and finally, after a thorough test had been made with a sample bronze carriage, the company was authorized to substitute bronze in place of steel for this casting. After this authorization, the company in a remarkably short time was able to effect delivery of a sufficient number of outfits to release all the subchasers and subsequently was able to maintain a schedule of deliveries sufficient to take care of urgent needs. Finally, before the cessation of hostilities, deliveries were sufficient to meet demands.

The American Steel Products Corporation had contracts totaling two hundred and twenty-five 5-inch mounts. This work was done at the Brantford, Ontario, plant, as before stated. Since practically all the materials used by the company for this work were bought in the States, it can easily be seen that it was at a disadvantage, especially when the complications introduced by two sets of customs authorities are considered. The company had an excellent plant and when materials were available did excellent work. The ending of hostilities found the company on the verge of making substantial deliveries of this much needed material.

The City Machine & Tool Co., of Dayton, Ohio, when the bureau was having great difficulty in obtaining satisfactory 4-inch sights, came to the rescue with a substantial production of acceptable materials.

Contracts were let to supply enough guns and mounts to arm practically all naval ships and merchantmen, which it was estimated would be taken over, built, or purchased by January 1, 1920, and to supply additional 4-inch and 5-inch mounts to England, France, and Italy. The following table indicates the total number of mounts ordered as a result of the United States entering the war, and the date that the first mount of each caliber was delivered on these war contracts:

Caliber.	Total number of mounts ordered.	Date of first deliveries on war contracts.
5 inch 51-caliber	1,705	Aug. 10, 1918
4-inch 50-caliber	5,010	Nov. 13, 1917
3-inch antiaircraft, 50-caliber	1,330	June 12, 1918
3-inch 50-caliber	2,170	Apr. 12, 1918
3-inch 23-caliber	1,100	Sept. 3, 1917
6-pounder	154	Sept. 8, 1917
1-pounder	1,700	Mar. 15, 1918

RUSSELL MOTOR CAR CO., SHOWING THE ASSEMBLY FLOOR FOR 3-INCH ANTIAIRCRAFT MOUNTS.

66–1

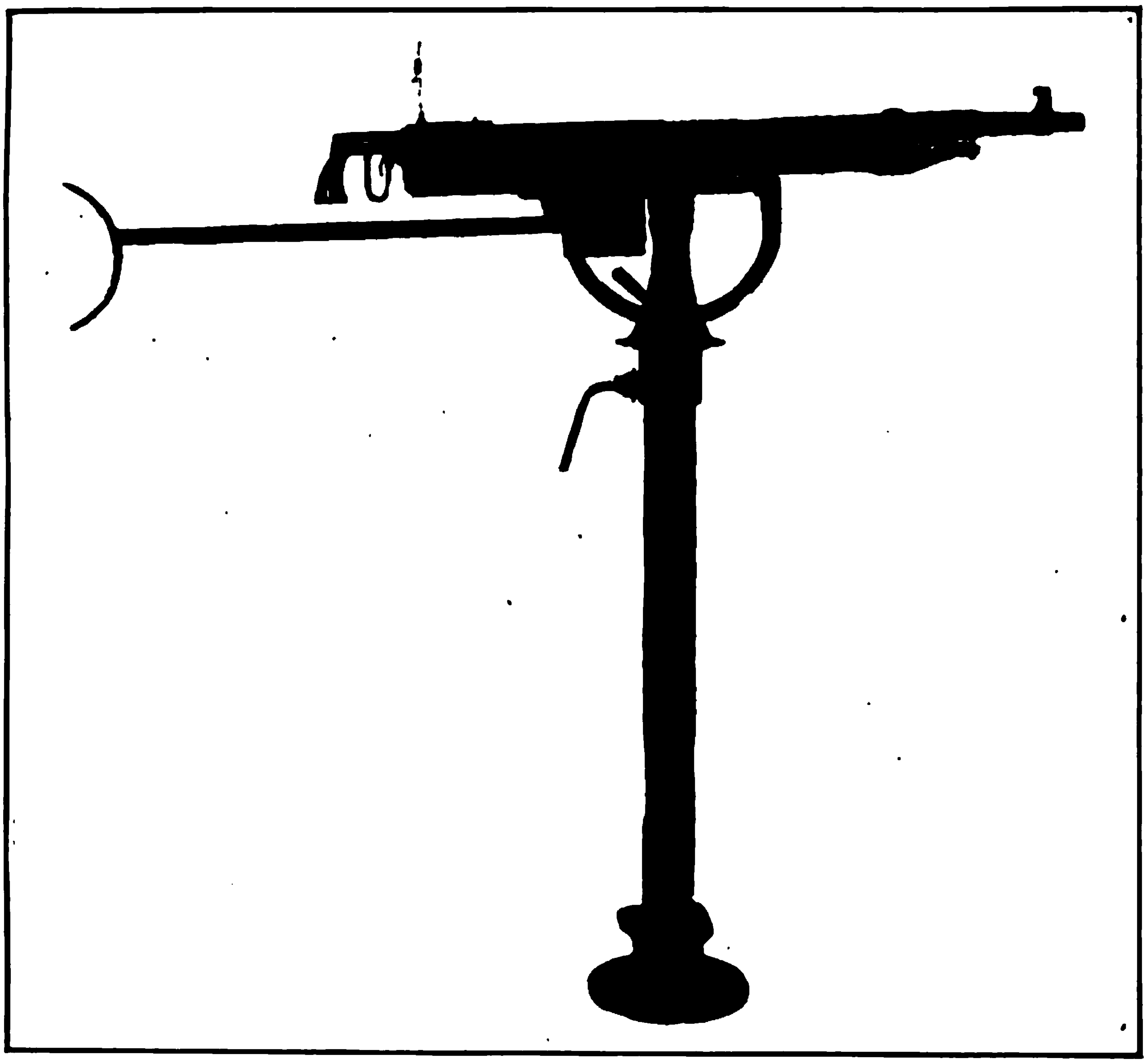
Ordnance Plant at South Charleston, W. Va., so as to provide for the manufacture of gun forgings as well as armor. Plans were worked out to provide a capacity of two sets of large gun forgings per month, with presses, cranes, and other machinery and equipment, capable of handling heavy gun forgings.

As a result of the war, there were a number of new types of guns developed and improvements effected in both guns and mounts.

The Y gun, or depth-charge projector, supplied for throwing heavy depth charges, proved one of the more important factors in combating the submarine. An 8-inch bomb-throwing howitzer was built, capable of throwing a projectile containing 70 pounds of TNT a distance of approximately 2,900 yards. The manufacture of 100 of these was started. The 3-inch 23-caliber boat gun was another new weapon.

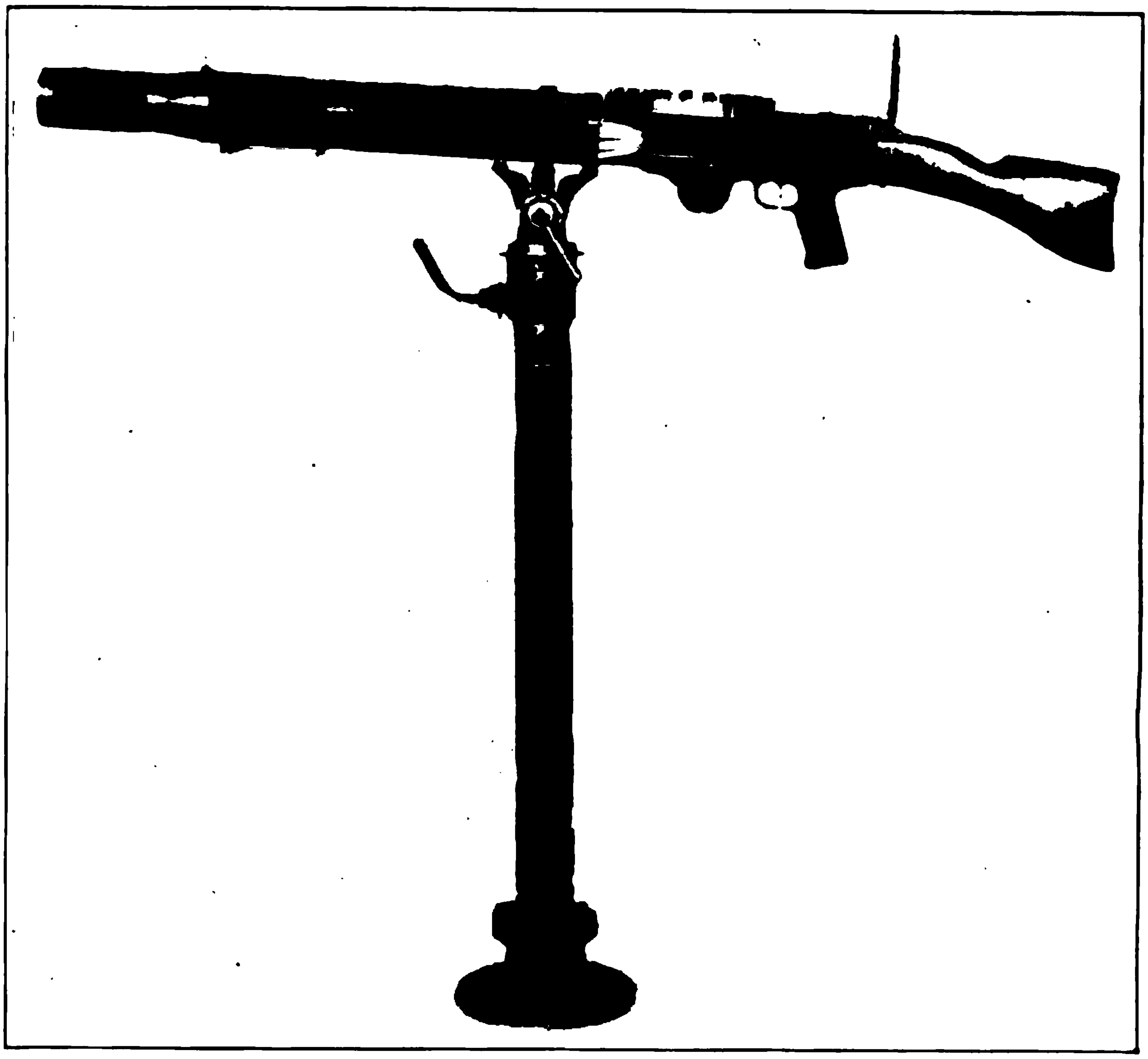
Most of the broadside guns in service were limited in range because, as mounted, the port sills prevented high angles of elevation and they were designed to care for only such moderate angles. No such restriction existed when guns were located on upper decks of merchantmen or transports. As the war went on the Germans put heavier guns on their submarines, which, because of the roll of the vessel in the seaway augmenting the angle of elevation provided by their mounts, were apparently able to outrange similar calibered guns on merchantmen or transports. It was essential then to increase elevation of guns and do it quickly. A limitation here is reached because of the difficulty encountered in the loading. The New York yard, under direction of Lieut. Commander R. W. Clark, solved this matter in a quick practical way by inserting a trunnion block in the old trunnion seats and adapting the training and elevating gears and the sight mechanisms to the new trunnion heights. This had the effect of increasing the angle of elevation and the resulting range of the gun by raising the trunnion height of the mount. The Naval Gun Factory made extensive studies based on this method of increasing the range of broadside mounts, with the result that the greatest practical elevation was given the intermediate guns of the service.

As the range of their guns was increased, it became the custom of the German submarines, whenever possible, to keep outside the range of the merchantmen they were attacking and, from this safe distance, to open fire. This method of attack was particularly dangerous in the case of the larger merchantmen, for they presented a large target for the submarine and still were, in some cases, not able to reply effectively because of the extreme range the submarine had selected. On the other hand, the smaller merchantmen, by keeping the submarine at these extreme ranges, lessened by so much their chance of being hit.



MARLIN ROCKWELL MACHINE GUN.

68-1



LEWIS MACHINE GUN.

Antisubmarine warfare brought out the need for quick slewing devices. Satisfactory devices were developed for all broadside mounts, and many of them were used in service.

Foot firing devices, with seats for pointers and trainers, were designed and sample installations made. This was a substantial improvement in the ease and accuracy with which the gun's crew could aim and fire the gun.

The housing type of mount for 3-inch 23-caliber guns, in use on submarines at the beginning of the war, proved unsatisfactory. A new design of 4-inch 50-caliber mount, to be housed in the superstructure, was developed, but before the type mount could be completed, the department decided upon a fixed "wet" type mount for submarines. In order to utilize mounts on hand, the latest type ot 3-inch 50-caliber and 4-inch 50-caliber mounts were modified to make them suitable for this purpose.

In an attempt to obtain sufficient pistols to meet the Naval requirements, the bureau in the early part of 1918 encouraged the Remington Arms, Union Metallic Cartridge Co., in the development of an automatic pistol, caliber .45. Upon test, this pistol proved superior to the type of pistol now in service. The manufacture of a quantity of these pistols was not authorized, however, because of assurances from the Army that the needs of the Navy could be more readily taken care of, under the manufacturing program for pistols established by the War Department.

In June, 1918, the bureau, in conjunction with William Reid & Sons, developed a .45-inch 50-caliber shoulder line throwing rifle for rescue purposes. This gun has been in service on naval vessels since the latter part of September, 1918, and filled an urgent need in the equipment of vessels passing through the war zone. The gun will throw a metal projectile attached to a light cotton line a distance of approximately 200 feet.

MACHINE GUNS.

Previous to the outbreak of the war, the Navy had a total of 800 machine guns—400 Colts, Mark I, model 1, and 400 Benet-Mercier, Mark II, model 1.

Several types of machine guns were tested just prior to the declaration of war, by representatives of the Bureau of Ordnance and the Marine Corps. The guns tested were Colt (Mark III), Berthier Automatic Rifle, Marlin, and Lewis. The bureau desired to obtain a heavy machine gun that could be fired from a mount on the deck of a destroyer or submarine chaser. The first satisfactory design submitted was the Colt, Mark III. This is an improved type of the old Colt, Mark I, model 1. Two contracts were placed with the Colt Patent Fire Arms Co. on March 24, 1917 and April 6, 1917, for a total of 1,500 of these guns. This gun is a good standard heavy

machine gun and, prior to the Lewis, it was the best in the service. All but 150 contracted for were in service when the armistice was signed.

The Marlin-Rockwell Corporation submitted the Marlin machine gun for test. This gun was a modification of the Colt, Mark III. It was air-cooled and gas-operated, substituting a piston action for the Colt flapping lever action. The guns passed a preliminary test and between February 27, 1917, and April 27, 1917, four contracts were placed with this company for 1,605 of these guns. All contracts were completed, but although the guns, when tested with 1916 Frankford Arsenal ammunition functioned satisfactorily, they would not function when issued to service with ammunition of current manufacture. The guns were then recalled and returned to the company.

The machine guns mentioned above were of the heavy air-cooled type and were not capable of meeting fully the requirements of either a machine gun or an automatic rifle, in that being air-cooled they were not capable of a sustained fire and were too heavy for use as an automatic rifle.

The Savage Arms Co., of Utica, N. Y., were manufacturing Lewis machine guns for the British to shoot .303-caliber ammunition. At the urgent insistency of the bureau several guns were manufactured to shoot .30-caliber ammunition, and these guns were tested on April 5, 1917, which date was practicable by the hard labor of the company under strong pressure from the bureau. As a result of this test the Lewis machine gun was adopted as a standard for the Navy, and on April 25, 1917, the first contract for 3,500 guns was placed with this company. Subsequent contracts to a total of 9,350 guns were placed. All of these guns were delivered with complete sets of barrels, spares, and luminous sights.

The Lewis gun, while not satisfying fully the requirements as given above for both the machine gun and the automatic rifle, yet is a very satisfactory compromise of both requirements. It is not too heavy to be readily carried and operated by one man and can be fired by a man lying prone, from a convenient rest or from the shoulder. Its cooling device, consisting of fine ribs of aluminum along the barrel and an outer casing, is very efficient and permits of a more sustained fire without overheating the barrel than is possible with either the Colt or Marlin guns.

The Berthier automatic rifle was tested in the summer of 1917, and after passing a successful preliminary test the Hopkins & Allen Co. were awarded a contract on February 2, 1918, for 2,000 of these rifles. The five models submitted on the original contract of December 2, 1916, were the only deliveries made, because the company could find no proper facilities for manufacture. The appro-

priation covering this order was diverted to the purchase of Browning automatic rifles, which were later furnished by Army Ordnance for use of the Marine Corps.

The Browning machine guns and automatic rifles passed satisfactory preliminary tests held by the Ordnance Department of the Army, after which the Navy purchased 2,000 automatic rifles and 400 machine guns to meet the requirements of the Marine Corps. The automatic rifle is much lighter than the Lewis and more easily handled. Its magazine capacity is, however, only 20 rounds. The Browning machine gun is much heavier than the Lewis gun, is water-cooled, has a belt feed, and therefore is capable of greater sustained fire.

Throughout the war the Navy was never hampered in its operations by lack of machine guns.

The following table shows the number of machine guns and automatic rifles delivered to the Navy between the period April 6, 1917, to November 11, 1918:

MACHINE GUNS AND AUTOMATIC RIFLES.

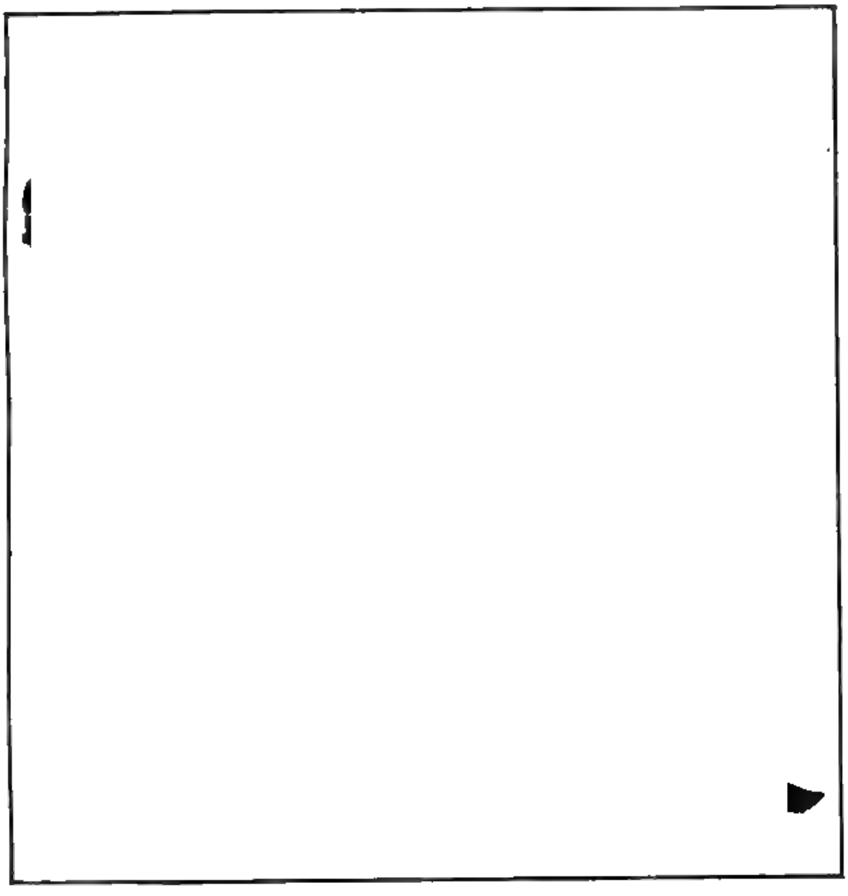
Type.	Mark.	Number delivered.
Colt	III	1,500
Berthier	IV	5
Marlin	V	1,605
Lewis	VI	4,204
Browning	Light	2,000
Do	Heavy	442
Total		9,756

All rifles, pistols, and landing-force equipment furnished during the war were procured from the Army. The Navy's demands for rifles and pistols were, however, never completely met. As the war continued, the needs, especially for pistols, grew faster than the supply. It had been understood early in the war that the needs of the Navy for this material would be taken care of by the War Department. In view, however, of the large number of pistols and rifles required by the Army, the War Department was never able to completely meet the demands of the Navy. On one occasion it became necessary for the Navy to return automatic pistols to the Army and accept revolvers in place of them.

The following table shows the small arms of various kinds which were delivered to the Navy during the period of the war:

SMALL ARMS.

Articles.	Delivered.	Articles.	Delivered.
Rifles, caliber .30 M-1903	31,375	Very signal pistols	20,000
Rifles, caliber .30 M-1917	2,000	Cutlasses	1,000
Rifles, caliber .30 dummy drill	10,000	Riot shotguns	1,700
Pistols, caliber .45	7,690	Line throwing guns	500
Revolvers, caliber .45	8,100	Rifles, caliber .22	200
Revolvers, caliber .38	8,100	Pistols, caliber .32	200



HEAVY BROWNING MACHINE GUN.

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CHAPTER V.

AMMUNITION.

Mention has been made in earlier chapters of the procurement of guns and gun mounts and the arming of vessels therewith. Naturally, however, these vessels and these guns are useless for the offensive unless an adequate ammunition supply is furnished for each gun. The problem of procuring such a supply was little less than that of procuring and mounting the guns themselves. The manufacture of the guns was a question of the production of a relatively small number of large units; that of the powder and shell rather a problem of quantity production of comparatively small units.

Prior to the war the bureau had provided all the vessels of the Navy with a full service allowance of ammunition, carried on board each ship in her magazines. In addition, a large reserve of ammunition for each ship was made up and stored at the several ammunition depots operating under the bureau. This, it was estimated, would provide for the initial needs during war of the ships of the Navy, and, as it proved, was more than enough for the vessels of the Regular Navy, since these vessels were to a large degree never engaged in actual combat.

The department's extensive program of target practice each year was provided for by procuring and issuing special target practice ammunition, distinct from the service allowance of the ships of the Navy, so that the service allowance might be kept intact.

At first glance, ammunition would seem to be largely a matter of powder and shell. On closer inspection, however, it is found that it comprises not only the smokeless powder but the silk bag or brass cartridge case in which it is contained; the primer, by which it is ignited in the gun; the ignition charge (the black powder to commence the burning of the smokeless powder); the mouth cup or wads, which seal the cartridge case; the shell; the explosive to go within the shell; and the fuse to cause the shell to burst.

The bureau's organization assigned to one section the procurement of powder, explosives, fuses and all so-called ammunition details except shell. To another section was assigned the procurement of shell. Since the bureau must also provide armor for our vessels,

and since the armor is closely connected with the shell as the means of defense against it, armor was also assigned in the bureau's organization to the shell section.

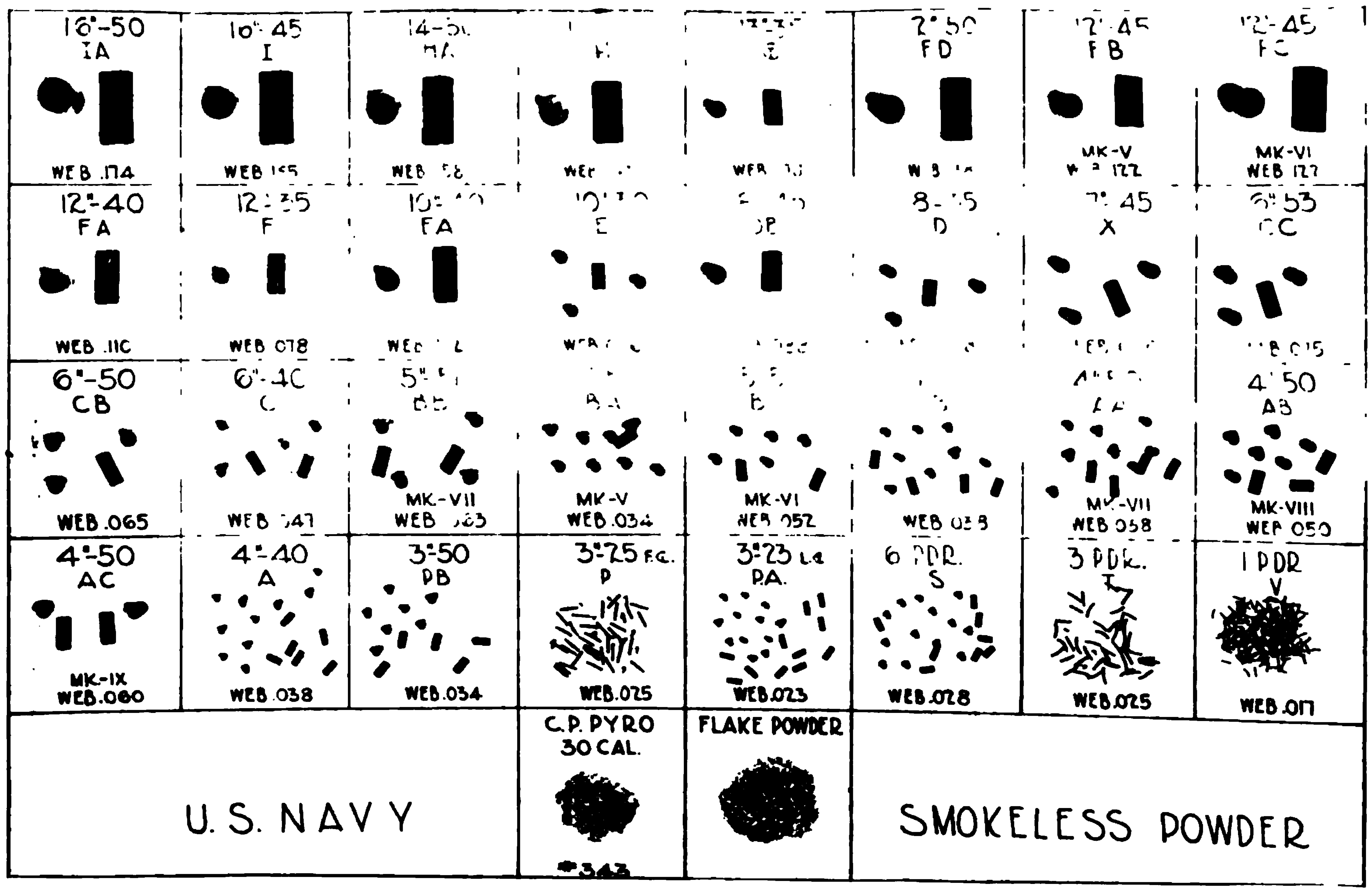
In addition to these sections of the bureau, there were major ammunition depots at Hingham, Mass.; Iona Island, N. Y.; Fort Mifflin, Pa.; St. Juliens Creek, Va.; Puget Sound, Wash.; and Mare Island, Calif., near the naval bases of Boston, New York, Philadelphia, Norfolk, Puget Sound, and San Francisco, respectively. These ammunition depots received the raw materials—powder, explosives, shell, fuses, cartridge cases, and other details—and loaded and assembled them into complete rounds of ammunition ready for firing. This ammunition was then issued by the depots to the ships. Prior to the war, as has been noted earlier, the bureau created reserve batteries for the arming of such merchant vessels as would be allocated to the Navy in case of hostilities. Ammunition for these reserve batteries was prepared and stored, ready for issue at the depots.

During the war, however, the vast number of merchantmen, patrol vessels, and other craft armed by the Navy brought demands upon the Navy's supplies of ammunition which required industrial expansion paralleling that necessary for the supply of guns.

A.—POWDER, EXPLOSIVES, AND FUSES.

Before the actual declaration of war, the bureau entered into extensive contracts for the production of explosives, powder, fuses, cartridge cases, and the other essentials of ammunition, and also obtained options on such production. This early action is one of the principal reasons why the bureau had ample ammunition to meet emergency needs at the very beginning of hostilities. Immediately after the declaration of war, the demands for ammunition and other explosive material grew enormously, and contractors who could take contracts for this material and who did not have their entire capacity obligated were called upon and contracts let.

In the manufacture of powder, immediate efforts were made to expand greatly the Naval Powder Factory at Indian Head, because the requirements of the Army were such as to take up practically all of the capacity of private companies. Owing to the isolated situation of Indian Head, and to its entire lack of railroad communication, every effort at expansion of industries at that place was doubly difficult. The expansion of the powder factory went on gradually, and, at the time of the signing of the armistice, had reached such a point that the production was in excess of the immediate needs of the Navy. It should be understood that, by expansion of the powder factory, it is not meant merely the expansion of the facilities for the manufacture of powder, but also that of the necessary plants for manufacturing nitric and sulphuric acids and ether.



VARIOUS SIZES OF POWDER GRAINS—U. S. NAVY SMOKELESS POWDER.

POWDER CHARGE FOR 14-INCH 50-CALIBER GUN. THE REGULARITY OF THE QUARTER CHARGES IS DUE TO STACKING OF THE POWDER GRAINS END ON END.

The bureau had several contracts for powder in effect at the time of the declaration of war. Negotiations were immediately commenced for the letting of further contracts; but, as is well known, there were only two or three companies prepared to manufacture smokeless powder for naval guns.

Early in the war, the bureau entered into a contract with the Du Pont Co. for 25,000,000 pounds of powder of various granulations. This contract called for 15,000,000 pounds of air-dried powder and 10,000,000 pounds water-dried, the latter being prepared by a much quicker process, suitable for powders of smaller granulations. The deliveries of powder under this contract were scheduled to commence in the early part of 1918. Such deliveries actually commenced in May, 1918.

Another contract was entered into with the Hercules Powder Co. for the delivery of 18,000,000 pounds of powder at the rate of 1,500-000 pounds each month, commencing February 1, 1918. This powder was all to be water-dried. Practically the entire amount was delivered during the period of the war.

Due to the contracts running at the time of the declaration of war, the new contracts let, the capacity of the naval powder factory at Indian Head, and the reserve stock of ammunition on hand at the various ammunition depots, the supply of powder for the Navy was adequate at all times.

The Navy's supply of fuses was kept at a satisfactory level at all times. When it became apparent that hostilities were imminent, steps were taken to increase the production of fuses. The number of companies in the field for the manufacture of fuses was not by any means so limited as was the case in the manufacture of powder. It was apparent that many companies, who had machinery for manufacturing small machined parts in quantities, would, with a little assistance and experience, be able to take up the manufacture of fuses. The bureau did not at any time establish a policy of adopting a standard type of fuse and requiring manufacturers to bid on this fuse. The policy was, at all times, to accept any fuse which would meet certain rigid specifications, conform to certain dimensions, and embrace the necessary safety features. By this means, the field for the manufacture of fuses was greatly broadened and the number of bidders, on practically all requisitions for fuses, was considerably increased.

The types of fuses used by the Navy were as follows:

A detonator fuse for use in projectiles with high explosive, which would give a slight delay before bursting the projectile. This detonator was designed for use in armor-piercing projectiles.

A detonator fuse similar to the above, but without the delay feature. This was designed for use in high-explosive projectiles not having armor-piercing qualities, such as those supplied for the railway batteries.

A time fuse, for shrapnel, star shell, and high-explosive projectiles intended for use against aircraft.

An instantaneous detonator fuse designed for use in flat-nosed projectiles, which were loaded with cast TNT and were primarily designed and issued for use against submarines.

A medium caliber tracer fuse, designed for use in medium caliber tracer projectiles loaded with black powder or mixed bursting charge. These fuses are non-delay fuses and are used in all medium caliber projectiles issued to vessels of the Navy.

A fuse similar to the above, but without the tracer element.

A minor caliber tracer fuse somewhat similar to the above-mentioned medium caliber fuse, but intended for projectiles of the smaller sizes, such as 3-inch, 6-pounder, etc.

A minor caliber fuse similar to the above, but without the tracer element.

The number of manufacturers who were able to make the detonator fuses above mentioned was very restricted, but ability to manufacture medium and minor caliber fuses was quite general.

The immediate equipment of section patrols, and the arming of merchant vessels, made a large drain upon the stocks of reserve ammunition on hand at the ammunition depots, this applying especially to medium and minor caliber ammunition, from 1-pounder to 6-inch, inclusive. In obtaining ammunition for these smaller guns, the promptness and ability of the Du Pont Co. to meet sudden calls was a great asset to the Navy. For example, 50,000 pounds of 1-pounder powder was delivered in a week after an urgent telephone order was given. Many of the smaller calibers of guns and older types of guns, for which little use was ever contemplated, were put into service and required complete allowances of ammunition. This was particularly the case with 6-inch 40-caliber, 5-inch 40-caliber, 6-pounder, and 3-pounder guns. The stocks of cartridge cases were very limited for all of these sizes, so that considerable difficulty was found in maintaining a sufficient number of cartridge cases to meet the needs of the Navy. The Naval Gun Factory cartridge shop made every effort to increase production of these odd sizes of cases and, so far as is known, no actual shortage of these cases, sufficient to prevent the issue of necessary ammunition, existed at any time.

A very large number of cartridge cases, however, became necessary for what might be termed the "standard types" of ammunition. These cartridge cases were secured from large brass manufacturing concerns, such as the Scoville Co., of Waterbury, Conn., the Gorham Manufacturing Co., of Providence, and the Toledo Brass Casting Co., of Toledo. These companies sent representatives to the Naval Gun Factory, and with the cooperation of the gun factory these representatives acquired sufficient knowledge of naval practice to turn out very satisfactory cartridge cases, in sufficient quantity to keep ahead of the increasing demand from the ships being armed by the Navy.

Up to the commencement of hostilities, practically all primers for the service had been manufactured at two of the Navy's establishments—the Naval Gun Factory, Washington, D. C., and the Naval Torpedo Station, Newport, R. I. Owing to the volume of other work which it was necessary for these stations to undertake, it was apparent that the bureau must find other sources of supply for primers of certain kinds. A large contract was, therefore, entered into with the International Arms & Fuse Co., of Bloomfield, N. J., for the manufacture of primers intended for use in cartridge cases. The delivery of these primers was entirely satisfactory and, coupled with the production of the Navy's establishments, provided an adequate supply at all times.

The Navy used principally three kinds of primers during the war; known to the service as B.L.R.C. (breech loading rifle combination), magazine extension primers and cannon primers.

The B.L.R.C. primers, for heavy guns, were all manufactured at the Navy's plants, principally at Newport.

The magazine extension primers were of two kinds, one being a strictly percussion primer with a very small black powder magazine capacity, the other a combination percussion and electric primer, with a larger magazine capacity. The differences in the design of these primers were due to the different characteristics of the ammunition of the guns for which they were intended. The straight percussion primer was intended for use in 3-inch guns, which are not fitted for electric firing and for which the powder charge is comparatively small. The combination electric and percussion primer was intended for use in all cartridge case guns above 3-inch, practically all of which are fitted for both electric and percussion firing, and in which the powder charge is comparatively large. It was not necessary to use a special ignition charge of black powder with either of these two primers, thus saving the large amount of work in the loading of fixed ammunition.

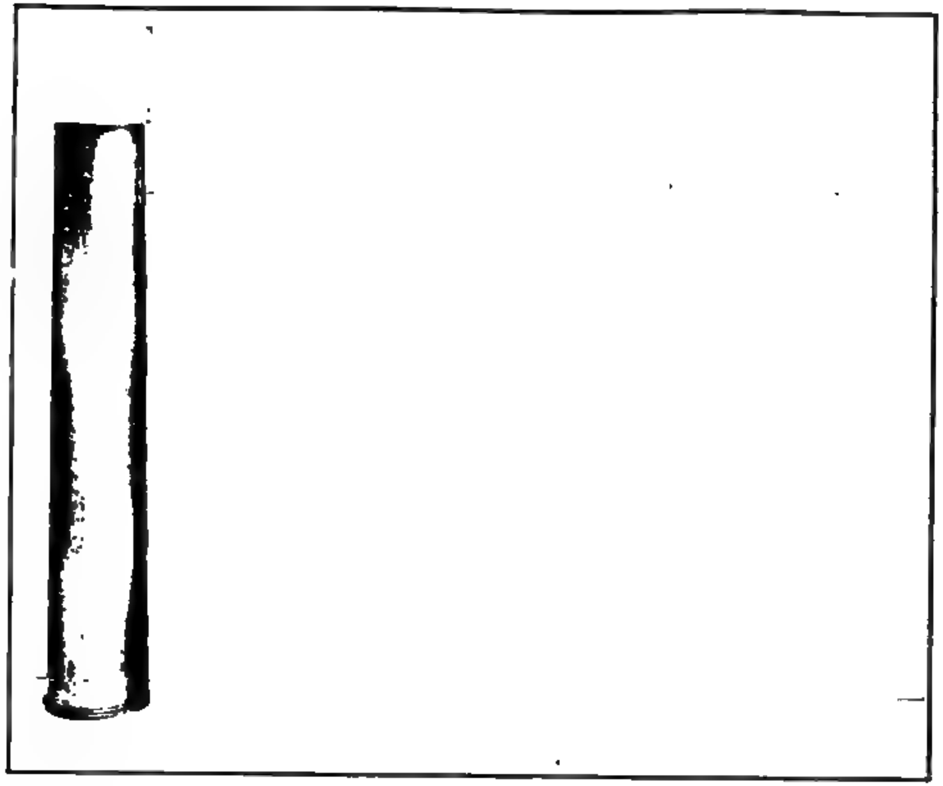
The cannon primer is a very small inexpensive primer intended for use only in such small ammunition as 6-pounder, 3-pounder, and 1-pounder.

The decision to prepare and send the Naval Railway Battery oversea resulted in a large drain upon the stock of 14-inch 50-caliber ammunition on hand. The only available supply of ammunition was that which was being prepared for the new battleships *New Mexico*, *Mississippi*, and *Idaho*. Since none of these ships were ready for commissioning at that time, practically all ammunition furnished to the Naval Railway Battery, and to the other 14-inch guns which were turned over to the Army, was taken from this stock. In addition to supplying all 14-inch 50-caliber ammunition to the Navy guns, a total of 1,800 rounds of this ammunition was supplied to the Army.

The powder supplied for the 14-inch railway batteries was, in all respects, the same as is ordinarily supplied to vessels for service allowance. The projectiles supplied for these batteries were of the same weight as the service projectiles, but were without armor-piercing qualities. By sacrificing the armor-piercing qualities the bureau was enabled to use a much larger explosive charge, which thus assured greater destruction when used against fortifications or troops. The fuses used in this ammunition were the standard United States Navy detonators, such as are available for use in naval ammunition at all times. All reports of the firings of these batteries indicate that the ammunition supplied was satisfactory in every respect and that it equaled the bureau's expectations in every case.

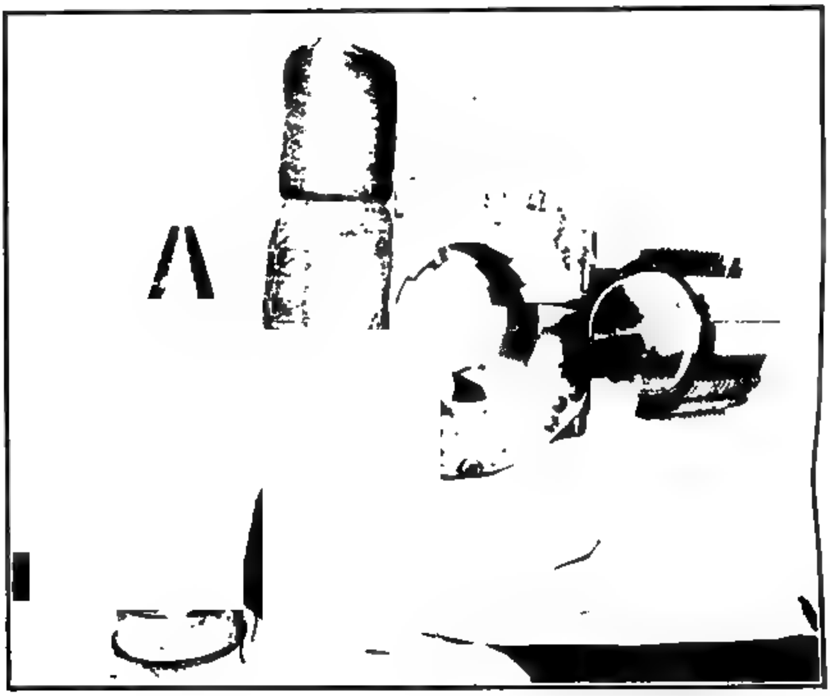
In general, the ammunition supplied to naval guns is divided into two classes, known to the service as "fixed ammunition," and "separate ammunition." The term "fixed ammunition" is generally accepted as indicating that which is made up one complete round to a cartridge. This round includes a projectile with bursting charge and fuse firmly seated in the mouth of the brass cartridge case, which contains the propulsive charge of powder and into which is inserted the primer. By "separate ammunition" is meant ammunition so made up that the loaded projectile is separate from the powder charge. In practically all of this separate ammunition, the powder charge is made up in bags which are loaded directly into the gun. In some of the old types of guns, the powder for this separate ammunition is placed in a brass cartridge case, the mouth of which is sealed by a cork plug.

All of the smaller sizes of ammunition are "fixed," while the larger sizes are "separate." Fixed ammunition includes 1-pounder, 3-pounder, 6-pounder, 3-inch field gun and landing gun, 3-inch 50-caliber and 4-inch. Separate ammunition includes everything larger than 4-inch. The 4.7, 5-inch 40-caliber, 6-inch 40-45-caliber, and



NAVAL CARTRIDGE CASES, FROM 1-POUNDER TO 6-INCH.

78-1



14-INCH PROJECTILE WITH UNSTACKED POWDER CHARGE.

6-inch 50-caliber English guns have the powder contained in a cartridge case. It is, of course, quite apparent that by far the greater number of rounds assembled are of the smaller sizes, but nevertheless the greater expenditure of powder is in making up the charges for the larger guns. To give an idea of the amount of powder required for a charge, the following weights of maximum charges are given:

1-pounder	grams	85
3-inch 50-caliber	pounds	4.25
5-inch 51-caliber	do	27
7-inch	do	62
12-inch 50-caliber	do	353
14-inch 50-caliber	do	480
16-inch 45-caliber	do	600
16-inch 50-caliber	do	720

In the preparation of powder charges, the fixed ammunition is naturally much more simply and rapidly prepared than the separate. In the former case, it is only necessary to put the primer in the cartridge case, put in the proper weight of powder, insert the necessary wads and distance pieces; and, then, force in the projectile by hand or by means of an hydraulic press. For separate ammunition, except when using cartridge cases, it is necessary to make up each powder charge in one or more silk bags fitted with an ignition charge at one end of each section, and then to place the powder charge in air-tight containers. When one considers that the number of sections, or bags, for a charge varies according to the size of the gun for which ammunition is being assembled and that, in the case of 12-inch and 14-inch, each charge requires four bags, in the case of 16-inch 45-caliber, five bags, and in the case of 16-inch 50-caliber, six bags, it will be seen that the preparation of a comparatively small number of charges means a considerable amount of labor.

All powder that is put up in bags is inclosed in a cartridge-bag made of pure silk. Although this might seem extravagant, it has been found necessary to use silk for cartridge-bag cloth, because cotton or other cheap materials leave a considerable amount of unburned residue in the gun, some of which would be smoldering and present a very grave danger when loading the next charge. The cloth used for this purpose is of two grades—the heavier cloth, which is used for the bag itself, and the lighter cloth, which is used to inclose the ignition charge. Both of these cloths have to be manufactured especially for cartridge-bag purposes.

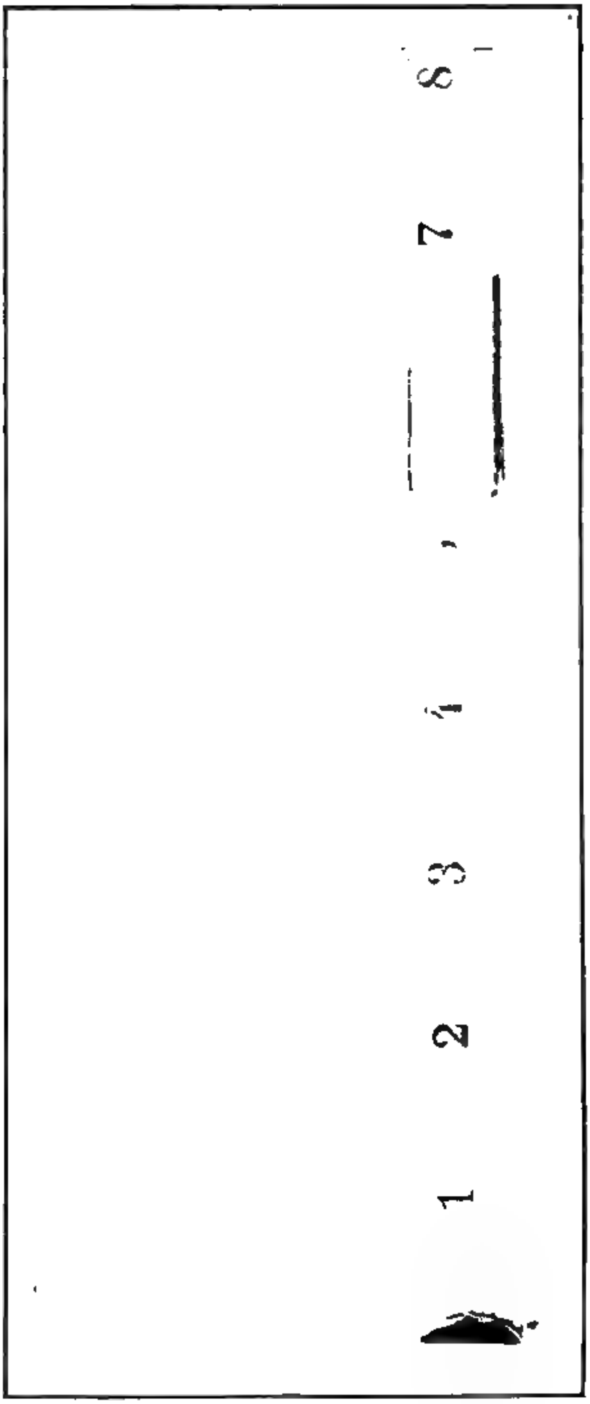
Smokeless powder ignites slowly and progressively, instead of almost instantaneously, as is the case with black powder. In order that the whole charge may be ignited with the least possible delay, and practically uniformly, an ignition charge of black powder is

used. In the smaller charges, this ignition charge is contained in the primer itself, but, in the larger charges, it is attached to each bag. This ignition charge is sewed up in the form of a flat disk between two pieces of thin cartridge-bag silk. The disk is then used as the base of the powder bag. When the flame from the primer strikes the ignition end, it quickly passes through the thin silk covering, ignites the black powder, and thus causes the spread of flame throughout the entire chamber of the gun and, consequently, throughout the entire charge of smokeless powder. In naval ammunition, all ignition ends are dyed red, while the rest of the bag is allowed to remain its natural color, that is, a grayish hue. The coloring of the ignition charge is essential, in order to be sure that the sections are placed in the gun with the ignition end toward the breech of the gun. In case the bag were placed in the gun with the ignition end away from the breech, it would be quite likely that the flame from the primer would not ignite the smokeless powder of the charge and, as a consequence, a hangfire or misfire would result.

It was formerly the practice to assemble all charges by merely dumping the powder into the powder bag, without reference to any regular order or arrangement of grains. This worked quite satisfactorily so long as powder charges were comparatively small and the chambers of guns fairly large. When, however, higher velocities became advisable and, as a consequence, the weight of charge was increased, both actually and in relation to the size of the powder chamber, it became necessary to adopt some system of packing or stacking the powder grains. This was particularly the case in the larger calibers, such as 12-inch, 14-inch, and 16-inch. This was accomplished by means of stacking machines developed at Bureau of Ordnance stations. By their use the charge is stacked; that is, each layer of powder grains is prepared by placing the grains on end and then forcing the layer into the cartridge bag. The charge, as prepared in a stacking machine, forms an almost perfect cylinder, being rigid and smooth on its sides. This eliminates one of the greatest difficulties with the unstacked charge; that is, the sharp corners of powder grains tending to cut through the cartridge-bag cloth while in the tanks.

After the charge is prepared, it is placed in one or more powder tanks which are air-tight. It is sent on board ship in these containers. The charge is not removed from these air-tight tanks until it is to be fired.

The number of cartridges, and charges prepared, will be indicated, as far as possible, under the remarks covering each individual ammunition depot.



DETONATOR FUSE FOR MAJOR CALIBER PROJECTILES.

80-1

TYPES OF PRIMERS USED IN CARTRIDGE CASES
FOR THE U. S NAVAL GUNS.

THE ACCIDENT ON THE STEAMER "MONGOLIA."

On May 20, 1917, when the steamship *Mongolia* was about 200 miles out of New York, the armed guard on board that vessel, in accordance with the usual procedure, commenced firing the 6-inch guns, for the purpose of practicing the crew in their use. Several nurses, belonging to a Red Cross unit en route for war service in Europe, were watching the firing from a seat on the promenade deck, some 175 feet forward and 10 feet above the gun. The shell and powder for these 6-inch guns are loaded into the gun separately; the powder charge is contained in a brass cartridge case, where it is held in place by a pasteboard wad, distance pieces, and a brass mouth cup that fits so as to make a moisture-proof joint; and when the gun is discharged, this brass mouth cup always is propelled in front of the gun some distance; sometimes whole, sometimes in pieces. On the third shot in this target practice, the mouth cup, after leaving the mouth of the gun, flew forward, boomeranged back to one side, and struck a stanchion near the nurses, the pieces of the mouth cup hitting and instantly killing two of the nurses, Miss Helen Burnett Wood and Mrs. Edith Ayres, of Chicago, and wounding slightly Miss Emma Matzen, also of Chicago. These unselfish women were on their way to the noble service of their profession in Europe. Their untimely death was deeply deplored by the whole country and cast a gloom over the Navy.

Immediately following the accident, the ship returned to port, and a board of investigation was appointed by the commandant of the Third Naval District, which board reported that the fatalities evidently resulted from the breakup and deflection of fragments of the brass mouth cup, and that no responsibility for the accident attached to the commander of the armed guard or any member thereof.

As is the case in all accidents when handling explosives, there was a lesson learned which was immediately put in practice, the result being that no more trouble with ammunition for these types of guns has been experienced since. It was found that use of the brass mouth cup was really responsible for this deplorable accident, and for it there was substituted a cork composition disk which effectually prevented further trouble.

The Bureau of Ordnance was investigated by the Senate Naval Affairs Committee for the accident on the *Mongolia*, the committee reporting in full to the Senate on June 27, 1917. This report set forth the facts as ascertained and commended the department for promptly recognizing the source of the trouble and making an efficient and successful effort to remedy it.

Back in the year 1904, the accident on the U. S. S. *Missouri* taught Ordnance officers and the country of the necessity of isolating handling rooms from turrets. Thus it is always with explosives, used, as they are always, under the most extreme conditions, conditions that can not be reproduced in laboratories; when the unexpected happens, it always points the way to effect certain changes that could not have been thought of otherwise.

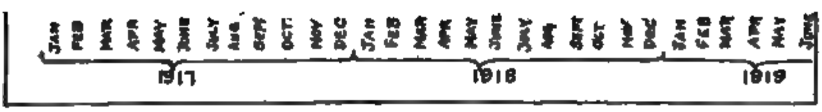
POWDER, EXPLOSIVES, AND FUSE SECTION.

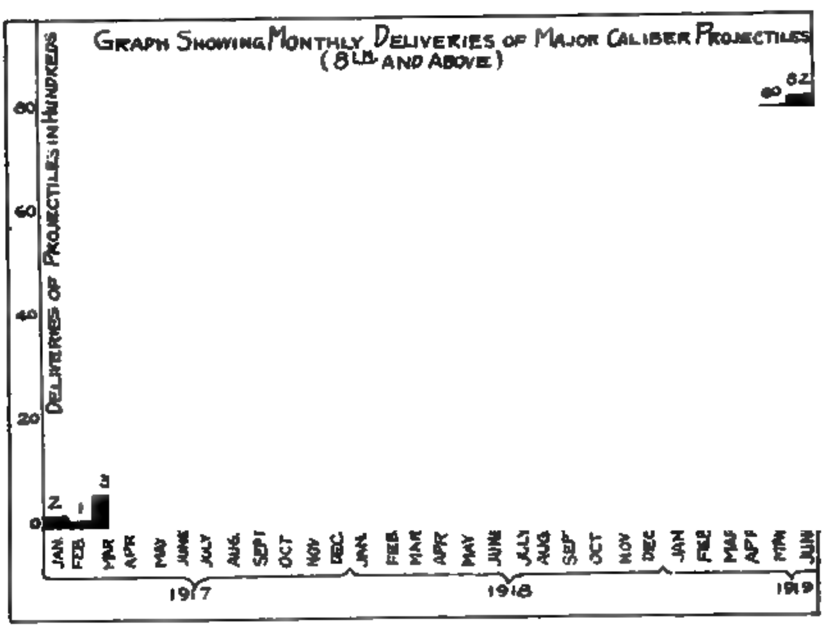
Previous to the war, the powder, explosives, and fuse section was a small organization, consisting of one officer, Lieut. Commander G. L. Caskey, U. S. Navy, one clerk and one stenographer. This personnel easily kept the work up to date and had time to delve into much experimental work in addition. The bureau's ammunition depots, which operate under the direction of this section, were small but well organized. The personnel at the ammunition depots was sufficient to care for the prewar work.

A short time previous to the war, when it became apparent that hostilities were imminent, expansion of all of the activities under this section was commenced.

One of the first moves was to separate experimental work from routine work of the section; this was done by the organization of an experimental section. The establishment of that section left the powder section free for administration and for the procurement, manufacture, and delivery of ammunition, pyrotechnics, and other necessary materials.

The personnel of the section was expanded as rapidly as possible. The work performed by the late Commander G. L. Caskey was especially notable and extraordinary. Commander W. W. Bradley in February, 1918, relieved Commander Caskey, who, at his own request, was ordered to sea duty on the U. S. S. *Oklahoma* as gunnery officer. Owing to the great need for seagoing officers afloat, it was impossible to obtain sufficient regular officers. The result was that this section of the bureau went through the entire war with only one regular officer attached to it. The section obtained, however, the services of Lieut. R. L. Lowman, of the Fleet Reserve Force, and of Lieut. R. Darling, of the National Naval Volunteers, very early in the war. These two officers proved of the greatest value during the period of hostilities. The commissioned personnel was further augmented from time to time by the enrollment of reserve officers as "Technicists," until a maximum of seven officers was reached. The clerical personnel was increased from time to time. The war personnel of this section will be found in Appendix II of this publication.


1917
1918
1919


Graph Showing Monthly Deliveries of Major Caliber Projectiles
(8 LB. and Above)
Deliveries of Projectiles in Hundreds
1917
1918
1919

B.—ARMOR AND PROJECTILES.

The declaration of war, April 6, 1917, found the Navy in a very satisfactory condition, in so far as projectiles for the existing Navy were concerned. There was an adequate supply of projectiles for all guns then in service and contracts had already been placed and deliveries were being made for such reserves as could be secured with the funds then available. Developments of the war to that date had disclosed the necessity for a few new types of projectiles, and experimental work had been carried sufficiently far to permit of contracts being placed for quantity production as soon as required.

The enormous expansion of the Navy and the consequent increase of gun orders resulted, however, in a vastly increased demand for projectiles; and, with this demand before the bureau, the following general principles were laid down as the doctrine to be followed in meeting the demand:

First. All projectile contracts were to be placed on the competitive bid, flat price contract basis, rather than on any cost plus scheme.

Second. Arrangements for assisting in the financing of projectile manufacturers had to be worked out.

Third. The closest kind of cooperation was to be arranged with the Ordnance Department of the Army in its similar work in order that there might be no conflicting demands on the manufacturers.

Fourth. The work of meeting the demands should be so placed that projectiles of one caliber or type would be manufactured in as few plants as possible, thereby concentrating the energies of the respective manufacturers on a single projectile.

Fortunately the large demand for shell was mainly for the smaller types, for use with guns of 7-inch caliber and below. The heavier projectiles, requiring complicated heat treatments to turn out the destructive armor-piercing shell, were needed only for the large vessels of the regular Navy. These vessels had been fully supplied before the war and few new heavy ships were commissioned during the war. In consequence, only the lighter, less difficult projectiles were needed and no great amount of experience was necessary on the part of the manufacturer. The problem was one of production in quantity, rather than of fine manufacture. But with the Allies and the Army clamoring for projectiles in vast numbers, this production problem was most difficult.

It is quite difficult to describe in detail the many obstacles which were surmounted in coordinating the work with the Army, and in building up production. The cooperation of the American Iron & Steel Institute, the War Industries Board, and the universally good relations which were maintained with Army Ordnance, all acted to keep the work moving. In some instances, contracts for projectiles, which the Navy had placed, were canceled by mutual agree-

ment, in order to release the plants involved to the Army; and, in a few instances, plants which had been busy on Army work were turned over to the Navy for naval work. Similarly, close cooperation was secured in the supply of rotating bands, which, throughout the war, was an exceedingly difficult problem.

By mutual agreement with the Army and the manufacturers, the Midvale Steel Co. and the Crucible Steel Co. were to supply the Navy with such armor-piercing projectiles as were needed to increase the reserve and to supply new ships. The success of the Midvale Steel Co., in meeting their deliveries and in producing an exceedingly fine type and quality of armor-piercing projectile, was a real accomplishment.

Reference to the projectile graphs will indicate the rate at which projectile deliveries increased. These graphs show more clearly than can words the enormity of the Navy's projectile needs and the rate at which these needs were met, a rate always kept equal to the demand.

Certain exceptional cases of the supplying of projectiles of peculiar design should be referred to.

Prior to the war, it had been apparent to the Navy that naval guns might be called upon to participate in land operations, either by actual bombardment by the fleet or by use of naval guns ashore, and the design of suitable projectiles was developed. Immediately that funds were available therefor, the bureau, in March, 1917, contracted for a supply of approximately 3,000 special high capacity, high-explosive projectiles, for the Navy's standard 14-inch guns; and the delivery of this entire order was completed in December, 1917. The wisdom of this move was later demonstrated, when the Navy railway battery was proposed, and these projectiles were used in France by that battery. It is interesting, in this connection, to note that the Navy turned over to the Army approximately 50 per cent of these projectiles, which number was in excess of the Navy's needs for its own batteries, for use in similar guns.

Similarly, it was decided that a high capacity, high-explosive projectile would be exceedingly effective for the high power 7-inch naval guns which were being made available for use ashore, and, on April 25, 1918, the bureau placed orders for a considerable quantity of such projectiles. Within one month of the placing of this contract, deliveries of projectiles had commenced. These projectiles were assigned to the 7-inch tractor mounts, when that project was launched. This type of projectile was exceedingly useful for such purposes and gave excellent range qualities.

The use of submarines by Germany called for the development of an entirely new kind of projectile. This projectile, called a flat-nose projectile, was so designed that it would not ricochet, but would

MANUFACTURE OF 14-INCH HIGH EXPLOSIVE PROJECTILES, PREPARED FOR INSPECTION.

MANUFACTURE OF 16-INCH A. P. PROJECTILES.

dive and continue in an underwater trajectory. The first contract for this type of projectile was placed June 19, 1917, and deliveries commenced in July, 1917.

ARMOR.

So far as armor was concerned, the situation was quite simple. Contracts had been placed for armor for all battleships which were authorized, and contracts were immediately placed for armor for battle cruisers which had been authorized. Very shortly afterwards, it was decided not to press the construction of capital ships, and, in consequence, the manufacture of armor gradually slowed up and was maintained at the least production compatible with the demands of the shipbuilders. In fact, the manufacture of armor in one of the armor plants was completely suspended in order to release the large armor press to the Army for the manufacture of certain howitzer forgings.

The manufacture of armor calls for exceedingly heavy equipment—huge furnaces, enormous hydraulic presses, and vast heating ovens. Armor is made in large plates. The steel is of special composition, melted down in open-hearth furnaces, forged into plates, annealed in great furnaces, then face-hardened by heating for weeks with granulated carbon on the face of the plates. The steel plate absorbs the carbon and makes a very hard surface which resists the penetration of all but the most powerful armor-piercing shell. The mass of the plate beyond the hard face is heat treated to render it tough and to resist the passage of the projectile even after the hard steel face may have been broken through. After these plates are manufactured they are installed in a line on the sides of battleships, to protect the vitals of the ship against the enemy's attack.

The Projectile and Armor Section at the outbreak of the war consisted of Commander R. S. Holmes, United States Navy, and one clerical assistant, Mr. W. T. Baker. The necessary war extension of this section brought it to a strength of three officers and three clerical assistants, at the time of the armistice.

C.—AMMUNITION DEPOTS.

Since the early operations of the bureau it has been found advisable to purchase or manufacture the essential elements of ammunition, but to combine such elements into the finished charges of ammunition at ammunition depots directly under the bureau's control. This practice, in force for many years, was continued most satisfactorily throughout the war. The Allies, and in some cases the War De-

partment, purchased complete rounds of ammunition as made by contractors, but the Navy made up all its ammunition at its own plants, directly responsible to the bureau and under the command of line officers of the Navy.

The ammunition depots of the Bureau of Ordnance are as follows: Hingham, Mass.; Iona Island, N. Y.; Fort Lafayette, N. Y.; Lake Denmark, N. J.; Fort Mifflin, Pa.; St. Juliens Creek, Va.; Charleston, S. C.; Mare Island, Calif.; Puget Sound, Wash.; Olongapo, P. I., and Kuahua, Hawaiian Islands.

In general all the ammunition depots on the east coast were fully occupied with work entailed by the war, but those on the west coast and in the Philippines had little additional work to perform during the war.

HINGHAM, MASS.

This depot is located on an arm of Boston Harbor, some 10 miles by air line from the navy yard, Boston. It consists of 904½ acres, acquired 1906–1912. It was commanded during the war by Lieut. Commander L. J. Wallace, United States Navy. Throughout the war it was called upon to supply a large amount of ammunition of small and medium sizes. In order to carry out the duties assigned, considerable expansion was necessary. Such expansion consisted of 1 shell house, 13 storage buildings, 2 minor storage buildings, and about 42 other buildings of miscellaneous character and description. At present the reservation of the ammunition depot at Hingham contains about 12 miles of railroad track.

IONA ISLAND, N. Y.

On the west bank of the Hudson River, 9 miles below West Point, is located the Naval Ammunition Depot, Iona Island, comprising 115.8 acres, acquired in 1900. During the war it was under the command of Commander J. N. Ferguson, United States Navy.

Owing to its location in the immediate vicinity of New York Harbor, this depot was the principal source of supply for a large part of the battle fleet, and for the greater part of vessels on transport and convoy duty. The following statistics of ammunition prepared at Iona Island during the war give a comprehensive idea of the activities of the depot, and are quoted at some length as an example of the work carried out at all depots:

Smokeless powder assembled into ammunition	lbs	11,633,218
TNT loaded into depth charges, naval defense mines, and projectiles	do	11,526,303
Explosive D loaded into projectiles	do	818,693
Black powder used	do	232,456

14-INCH COPPER ROTATING BANDS READY FOR ASSEMBLY ON PROJECTILES.

MIDVALE NAVAL 14-INCH ARMOR-PIERCING PROJECTILE AFTER PENETRATING A 13½-INCH CLASS A ARMOR PLATE.

96—2

GENERAL VIEW, NAVAL AMMUNITION DEPOT, LAKE DENMARK, N. J.

POWDER STORAGE HOUSES, NAVAL AMMUNITION DEPOT, LAKE DENMARK, N. J.

Fixed ammunition assembled ______ rounds	610,378
B. L. R. charges prepared	89,548
Projectiles, loaded and fused (35,510 major caliber)	477,243
Depth charges loaded	43,466
Naval defense mines loaded	1,132

Ammunition was issued to a total of 1,356 separate vessels, with a total of 3,455 deliveries, itemized as follows:

	Vessels.	Issues.
Regular Navy	261	961
Merchant vessels and transports	628	1,597
Patrol boats and submarine chasers	308	699
Foreign vessels	159	198
	1,356	3,455

Consignments of ammunition to United States bases abroad were made in 79 cargo shipments, which were destined to 17 different bases.

The depot made 39 cargo shipments of ammunition and mines to foreign governments, itemized as follows:

Italian	19
French	13
British	5
Cuban	2
Total	39

The following number of B. L. R. charges were prepared at Iona Island during the war:

14-inch 50-caliber	6,392
14-inch 45-caliber	6,962
13-inch 35-caliber	128
12-inch 50-caliber	1,397
12-inch 45-caliber V-5	621
12-inch 45-caliber V	410
12-inch 40-caliber	94
10-inch 40-caliber	56
8-inch 45-caliber	10
8-inch 35-caliber	128
7-inch 45-caliber	25
6-inch 50-caliber	19,795
5-inch 51-caliber	45,376
5-inch 50-caliber	8,154
Total	89,548

Fixed ammunition prepared at Iona Island during the war is as follows:

6-inch 40-caliber	1,978
5-inch 40-caliber	9,542
4.7-inch	500

4-inch 50-caliber	37,513
4-inch 40-caliber	14,357
3-inch 50-caliber	161,757
3-inch L. G.	30,739
3-inch Davis	15,400
3-inch Davis	13,400
6-pounder	67,397
3-inch Davis	15,400
3-pounder	18,981
1-pounder	234,456
Y-gun No. 1	13,404
Y-gun No. 2	2,600
Y-gun No. 3	1,801
Total	626,178

The following depth charges were loaded at Iona Island during the war:

Mark I-1	10,065
Mark II	90
Mark II-1	9,947
Mark II-2	16,464
Mark IV	82
Type D British	6,818
Total	43,466

Projectiles.—In order that a large tabular list may be eliminated, it is sufficient to say that during the war Iona Island loaded and fused 477,243 projectiles of all classes, of which the following gives a good idea of the distribution:

14-inch armor piercing	13,837
6-inch common	11,847
5-inch 50-pound long point	50,327
4-inch long point	27,985
3-inch 50-caliber	113,799

The land available at the ammunition depot at Iona Island was not sufficient to allow of any considerable expansion at that station. The buildings constructed at Iona Island during the war were one Marine Barracks, two storage buildings, two shell houses, two fuse houses, 11 other buildings, and several extensions to existing buildings.

FORT LAFAYETTE, N. Y.

Fort Lafayette is a small ammunition depot located in New York Harbor. This depot is used for the issue of ammunition to ships, and for receipt of small quantities of ammunition from ships. It has no facilities for the preparation of ammunition but is an adjunct to the ammunition depot at Iona Island. During the war this depot delivered the following ammunition to ships in New York Harbor:

Cartridges, complete	404,146
B. L. R. charges	60,542

5-INCH PROJECTILES READY FOR FINAL INSPECTION.

PROJECTILE HOUSE, NAVAL PROVING GROUND, INDIANHEAD, MD., SHOWING SLUGS AND OTHER TYPES OF PROJECTILES.

88-2

Depth charges	6,627
Y-gun charges	9,391
Small arms ammunition, rounds	14,266,366

In addition to serving as a ready issue depot for the United States Navy, the ammunition depot at Fort Lafayette was utilized for the storage of miscellaneous lots of ammunition.

LAKE DENMARK, N. J.

Under the charge of the commanding officer of Iona Island is also the ammunition depot at Lake Denmark, N. J., situated about 7 miles from Dover, N. J., and comprising 460 acres, acquired 1892–1918. This depot is a storage depot only. No work of assembling, breaking down or issuing of ammunition is done from this section. Ammunition details are received either direct from the manufacturers, or from other depots, and are forwarded to such points as the bureau may desire, when necessity arises.

The depot at Lake Denmark is the Navy's largest storage depot. It was considerably extended during the war by addition of about 67 acres of land, and 183 new buildings and extensions of considerable magnitude were erected in the same period of time. In order to give an idea of the expansion of this depot during the war, it is only necessary to state that during the year 1916, 173 freight cars were handled; during 1917, 786 were handled; and during 1918, 3,822 were handled.

FORT MIFFLIN, PA.

The ammunition depot, Fort Mifflin, is situated on the Delaware River 8 miles south of Broad Street Station, Philadelphia, and about midway between the navy yard and great shipbuilding plant at Hog Island. It comprises 297½ acres, and was commanded during the war by Commander G. S. Galbraith, United States Navy.

To give an adequate idea of the activities at Fort Mifflin the following brief tabulation of a part of the work carried on is given:

Total number of cartridges assembled	607,286
Total number of B. L. R. charges assembled	48,867½
Total number of projectiles loaded	982,707

The bureau installed, and operated during the war, a plant at Fort Mifflin for the casting of TNT into projectiles. Such projectiles were used principally for defense against submarines and against aircraft. A total of 314,955 projectiles of all calibers were loaded with cast TNT at Fort Mifflin. These projectiles ranged all the way from the small 3-inch flat-nosed projectiles to the large 8-inch howitzer shells.

Like the other larger ammunition depots on the East coast, Fort Mifflin has been considerably enlarged during the war. Approxi-

mately 30 buildings of various descriptions were erected at the depot in this period, and 150.5 acres purchased.

ST. JULIENS CREEK, VA.

The ammunition depot, St. Juliens Creek, comprising 238 acres, acquired 1896–1917, is located on the western banks of the southern branch of the Elizabeth River, 3 miles from the navy yard, Norfolk, Va., in the immediate vicinity of Hampton Roads and within easy reach of one of the main bases of the fleet. On this account it was very largely used for the issue of ammunition to vessels of the fleet and to merchant vessels. The activities at this depot were of two distinct characters; one, the preparation, assembly, and storage of ammunition; the other, the operation of the Navy mine-loading plant. This depot was greatly enlarged during the war, and a considerable amount of new construction was carried out. Approximately 48 new buildings, or extensions to existing buildings, were constructed. The issue of ammunition from St. Juliens was exceedingly large. A large amount of ammunition was forwarded from other depots to be delivered to vessels, to which it was consigned by St. Juliens. A great mine-loading plant, described in a later chapter, was erected and operated here.

This depot was commanded during the war by Commander W. L. Pryor, United States Navy.

CHARLESTON, S. C.

A small storage ammunition depot was maintained here during the war.

MARE ISLAND, CALIF.

The ammunition depot, Mare Island, is located on Mare Island not far from the Mare Island Navy Yard.

No extensive work was carried out on the west coast during the period of the war. This was due to the concentration of almost the entire Navy in the Atlantic. Anticipating the movement of the fleet to some extent to the west coast, the areas of the ammunition depot at Mare Island were considerably enlarged, and 29 new buildings of various kinds were erected. The present movement of the fleet to the west coast has justified the expansion of this depot.

On July 9, 1918, at 7.55 a. m., a serious explosion of 125,000 pounds of black powder occurred at this depot from causes as yet unknown, despite the complete investigation carried out by the orders of the Secretary of the Navy. Six fatalities resulted from this explosion.

With this exception, the ammunition depots operated throughout the war without major accident.

3-INCH 50-CALIBER SHRAPNEL CASES READY FOR FILLING.

90-1

ARMOR-PLATE SAWING MACHINE.

90-2

PUGET SOUND, WASH.

The ammunition depot, Puget Sound, is situated on the west shore of Ostrich Bay, Kitsap Point, Wash., 3¼ miles from the Puget Sound Navy Yard; it comprises 256 acres, acquired in 1904.

For the same reasons which prevailed at Mare Island, very little work was carried out at Puget Sound while the entire fleet was in the Atlantic. Twelve new buildings were erected and the depot was put in proper shape to handle such increased activities as might result from the transfer of a part of the fleet to the Pacific.

KUAHUA, HAWAIIAN ISLANDS.

The ammunition depot at this point, near the navy yard, Pearl Harbor, was under construction during the war, but did not begin operation until 1919.

OLONGAPO, P. I.

This depot is located at the naval station, Olongapo, some 60 miles from Manila in the Philippine Islands. It is charged with the preparation and upkeep of ammunition for the vessels of the Asiatic Squadron, and also operates a chemical laboratory for routine tests of powder and explosives. It was commanded during the war by Lieut. Commander W. P. Williamson (now deceased), later relieved by Lieut. H. A. Davis. Owing to the reduction of the United States Asiatic Fleet during the war but little other than routine business was carried out at this station.

D.—EXPLOSIVES—RAW MATERIALS.

In the production of most of its munitions of war, the bureau found that it need deal only with the finished product, or at any rate with substances several steps removed from the raw state. Thus, guns could be obtained from steel furnished by the great steel companies, and the bureau concerned itself with provision of facilities for forging and machining the steel billets. Similarly with projectiles, cartridge cases, and all the elements of ammunition except explosives.

With explosives, however, the bureau found it necessary to extend its activities to the provision of some of the elemental materials. The country's supply of raw materials for the manufacture of explosives was strained, even before the entrance of the United States into the war, by the enormous demands of the Allies. With the United States at war, these demands had to continue to be fulfilled in order to further the allied cause, and, in addition, the vast supply of explosives necessary for the American forces must be furnished.

Explosives of both sorts were needed, propellants and bursting charges, the propellants to fire the projectile from the gun and the bursting charges to explode shells, mines, torpedoes, and all the kindred weapons. The propellant for both Army and Navy was, of course, smokeless powder, employing in its manufacture the major elements of cotton, sulphuric acid, and nitric acid, and in smaller quantity alcohol, ether, and diphenylamine. Cotton existed in plenty. Sulphur could be mined in Louisiana. Alcohol and ether could be made from the national supply of grain. Diphenylamine, in the relatively small quantities needed, was not a serious matter. The nitric acid, however, was alarmingly short. All the powder factories of the country needed it, and the only source of supply was that manufactured from sodium nitrate, which had to be secured at great expense of shipping, otherwise needed in the war, from Chile. Platinum, largely used in the manufacture of sulphuric acid, was also very short.

For bursting charges, a high explosive was desired. Trinitrotoluol possessed the most serviceable properties for use. The supply of toluol was scant. Ammonium nitrate could be used. Both these explosives, and in fact all other possible substitutes, required nitric acid or nitrates, and most of them required sulphuric acid as well.

The bureau soon found, therefore, that it was impracticable to place orders for the finished explosive, but that it was necessary to provide for the manufacture of even the most elemental raw materials.

The Navy's demands for explosives were much smaller than those of the Army, but the bureau did not feel, nor in fact would the War Industries Board support such action, that it could demand the entire stock of sodium nitrate necessary for the manufacture of its smokeless powder and high explosives. Accordingly, like the Army, though on a smaller scale, it undertook the construction of a plant for the synthetic production of nitric acid from the nitrogen and oxygen of the air. After careful examination of the several processes available, the bureau decided upon the de Jahn process (a modification of the original German Haber process), as operated on a small scale by the General Chemical Co. The plant was to be located on newly acquired Navy land on the Potomac River, immediately below the naval proving ground at Indian Head, Md. This location was chosen in order that the nitric acid might be immediately available for use in the powder factory at the proving ground. The plant was designed to produce sufficient nitric acid to supply the powder factory's increased capacity of 100,000 pounds of smokeless powder per day, requiring therefor a daily production of 115,000 pounds of nitric acid. The process of manufacture belongs to the classification of direct synthesis of ammonia from nitrogen and hydrogen. A

ARMOR TEST PLATE AFTER SUCCESSFUL BALLISTIC TEST.

92-2

THREE-GUN TURRET PORT PLATE AFTER BORING OUTLINE OF GUN PORTS.

mixture of one part nitrogen and three parts hydrogen passes under pressure over a suitable catalyzer at a high temperature causing the hydrogen and nitrogen to unite and form ammonia, $N_2+3H_2=2NH_3$. A single passage of this mixture through the apparatus causes a transformation of from 2 to 6 per cent of the nitrogen to ammonia. This ammonia being then recovered from the apparatus by condensation and the remaining and much larger portion of the gases uncombined returning to the cycle. It is the development of the ammonia process to which Germany owes its present independence of an imported supply of nitrogen. The catalyst used in the process is a secret, but is inexpensive as compared with the catalyst used in the Haber process and the pressures in the cycle of operations are much less.

The yield of nitric acid from ammonia by oxidation methods is very high, representing 90 to 95 per cent of that theoretically expected. The oxidation process will follow the Ostwald method in which the reaction $NH_3+4O=HNO_3+H_2O$ is brought about by passing the mixture of gases over platinum gauze or screen at high temperature (an exothermic reaction), at a velocity of some 2 meters per second. The time of contact between gas and catalyzer does not exceed one one-hundredth of a second. These oxides of nitrogen pass into the acid towers where water absorbs the gases forming weak nitric acid which is concentrated by a method of distillation after mixing with sulphuric acid. From this is obtained the fortifying acid used in the manufacture of powder.

Contract was let for the manufacture of this plant to the J. G. White Engineering Co., of New York, in conjunction with the General Chemical Co. The estimated final cost of this plant was $9,150,000, and an appropriation of that sum was obtained in the naval act of July 1, 1918.

Contracts were placed and construction begun in the summer of 1918, and every effort made to rush completion by the spring of 1919. At the armistice, however, all construction was stopped and contracts canceled.

The difficulty of this project may be understood when it is realized that not only was it a question of constructing a new plant, but also a new industry, since no large scale plant for the production of synthetic nitric acid existed outside of Germany, and the development of this plant called for expansion of laboratory processes into full manufacture in a far shorter time than would ordinarily be required. The War Department was proceeding with greater plans for nitric acid plants at the same time, and both Army officers and officers of this bureau cooperated in the development of the Army plants and of this Navy plant. Complete cooperation was, however, im-

practicable, since the Navy type of process was slightly different from that selected by the Army.

With high explosives a similar situation existed. The Navy's demand for TNT for mines, bombs, torpedoes, and projectiles, reached 50,000,000 pounds per year. Although this was well within the maximum TNT production of this country and Canada, which approached 200,000,000 pounds per year, obviously, when the Allies and the Army were likewise in need of vast stores of this material, totaling more than the available supply, the bureau could not expect to be allowed its full needs. A new high explosive had to be developed and a supply thereof procured. After a very careful survey of the high explosive field and considerable experimentation with different compounds, the bureau selected trinitroxylol, or TNX, as the most suitable for Navy purposes. This explosive requires both nitric and sulphuric acids. It does not, however, require toluol, which was really the limiting factor in the country's production of TNT. Xylol, the basic material, is the next hydrocarbon in the so-called benzene series to toluol. TNX possesses somewhat similar explosive properties to TNT, although it is not so readily molded into mines and other containers. In combination with a small amount of TNT, however, TNX forms a very satisfactory mixed explosive.

TNX had not been manufactured on a large scale in this country. Placing its reliance upon the efficiency of the Du Pont Co., however, the bureau authorized the construction by that company of a plant capable of producing 30,000,000 pounds per year of this explosive. The construction and operation of this plant by the Du Pont Co. marked still another of the great industrial achievements of this war. The contract was awarded in March, 1918, involving a plant costing $3,900,000; work was started even before the final papers were signed; part of the plant was in operation in October, 1918, producing satisfactory TNX, and the whole plant would have been in operation by December 1 had not the armistice caused the cancellation of the contract.

When it is realized that this marks not only the construction of a great plant but also the development from the laboratory to the industrial production of a comparatively unknown high explosive, great credit must be extended the Du Pont Co.

Once the TNX contract was let, the bureau was obliged to make further provision to assure the Du Pont Co. of an adequate supply of the raw material, xylol, for the subsequent manufacture therefrom of the finished TNX. Like toluol, xylol is a product of coke oven gases, oil refineries, and other sources from which hydrocarbons are obtained. No one or no two sources could supply even a small fraction of the xylol necessary. Even when the xylol was secured it must

ERECTING A LINE OF SIDE ARMOR IN ARMOR MACHINE SHOP, MIDVALE STEEL CO.

94-2

TURRET BARBETTE ARMOR ERECTED IN SHOP FOR ASSEMBLY TESTS.

be refined to the proper purity for the subsequent manufacture of the high explosive. Accordingly, the bureau negotiated contracts with the Barrett Co. for the distillation and purification of the xylol, and with some hundred different plants throughout the country to secure the necessary crude xylol to supply the Barrett Co. for their operations. The country was literally combed to obtain every available gallon of this crude xylol.

Again, with regard to platinum needed for the sulphuric acid required for its powder and high explosives, the bureau found it necessary to arrange with the War Industries Board and with all available sources of platinum, that it might be assured of sufficient quantity of this rare metal to supply not only its own powder factory at Indian Head, but also its new plant, operated by the Du Pont Co. for TNX.

For the great amount of administrative work involved in the above projects, a special section of the bureau was created, headed by Lieut. Commander Donald Riley, R. F., who also discharged coordinate duties as chief of the chemical division of the Bureau of Supplies and Accounts. The work of the section multiplied rapidly and at the end of the war Lieut. R. E. McConnell and nine other officers of the Reserve Force, all of chemical experience, and a number of clerical assistants, were engaged in the work of providing explosive raw materials.

After the armistice practically all the contracts within the duties of this section were immediately canceled and the section quickly dissolved, its officers returning to civil life. Lieut. McConnell, however, remained with the bureau for some little time, and made a special trip to Ludwigshaven, Germany, to obtain from the vast Haber nitrogen fixation plants at that point all the information possible as to the manufacture of nitric acid, in order that, should the need arise to proceed with the creation of a nitric acid plant in the future, the bureau might be better prepared. Lieut. McConnell's inspection of the nitrate fixation plant at Oppau proved most valuable. This plant at Ludwigshaven had a capacity of 100,000 tons per year or 10 times that of Army plant No. 1, located at Sheffield, Ala. The plant had been running day and night since early 1915 and was only interrupted during the whole war 12 hours because then a bomb in an air raid had struck a water tank. The German Government started this enterprise in 1907, but not until the beginning of the year 1914 were they certain that the process adopted would be a success. In addition to this plant, there is a large plant on the outskirts of Berlin, one and one-half times it in capacity. These two plants combined gave Germany a greater capacity for nitrogen than did the total amount of nitrate imported from Chile by all the Allies during any one year.

In other words, the German war capacity during the war was 100,000 tons per annum at Oppau, plus 150,000 tons per annum at Spandau, Berlin, of fixed nitrogen. The actual yield in acid from fixed nitrogen is to sodium nitrate as 450 is to 66.9 or equal to 6.7, thus 250,000 tons of fixed nitrogen is equal to 1,675,000 long tons of $NaNO_3$. Germany had on hand in January, 1915, some 750,000 tons of Chile saltpetre. By the capture of Antwerp some 200,000 tons of this material had been secured.

CHAPTER VI.

DEPTH CHARGES.

During the development of the submarine, prior to the World War, its possibilities as a weapon of offense were but vaguely conceived. Defense against submarines, however, except possibly for a few advanced thinkers, was confined to the general doctrine of the gun and torpedo, as applied as well against surface vessels. While conceding the possibility and probability of the submarine submerging to escape gunfire, it was generally believed that during his preparations for submerging or, when submerged, during his intermittent appearances on the surface to take aim, he might be struck by gun or by torpedo. With the development and use of the submarine on a large scale by the enemy, it became apparent that every possible means must be employed to destroy the submarine. It was apparent that the opportunities of catching him on the surface with vessels of superior gunfire were scant, as, by reason of his low freeboard, he could detect the approach of a hostile vessel, and immediately submerge before that vessel could sight him. By improvements in the construction of the submarine and by intensive training of its crew, the time of submerging was reduced, so that, even if "caught napping" on the surface, he might well submerge to safety before a hostile vessel could get his range and sink him by gunfire.

Again, with the skillful employment of periscopes, the submarine, during an attack, came to make fewer and fewer appearances, even of the periscopes, above the water, so that the opportunities for gunfire against him were most limited.

In other words, the submarine when discovered could submerge and escape with absolute impunity, or could effect an attack with little danger of injury except by an occasional lucky shot or by ramming. We may well imagine the commander of a submarine submerging before the approach of a hostile vessel and laughing derisively (if he chose no more active reply) as his opponent passed harmlessly over him.

Obviously, both as a means of exterminating the pest of the seas in hunting him, and of counter attack upon him when he attacked a

vessel, some method of "getting at him" under the water was necessary.[1]

In the early days of the war, this question became most acute, and both British and French devoted themselves to its solution. An effective answer to the problem was soon found. An explosive charge dropped upon the submarine would, if it struck him, blow a hole in him and sink him. The use of a contact firing gear, however, would make the explosive charge useless, unless it actually "bumped" on the submarine. If, however, the charge should not actually strike the submarine, but should explode in the water a short distance away, the relative incompressibility of water would permit the transmission through it of the hammer blow of the explosion, striking the submarine with a force similar to that of a "water hammer" in a pipe. This blow would prove sufficient to injure the submarine and, at very close range, to sink him.

Accordingly, what was desired was not so much a contact charge, which would function only on striking the submarine, but an explosive charge, which would fire in the vicinity of the submarine. This could best be realized by so regulating the charge as to explode at a given depth of water.

Various means of effecting this explosion were tested, including slow-burning time trains, buoys paying out wire, and hydrostatic-pressure devices. After considerable experiment with the various types, it was decided that the hydrostatic pressure was the simplest and the most suitable, and it is this type which is in general use in the United States and foreign navies.

Prior to the entrance of the United States into the war, the use of depth charges had begun, but was not carried out to any marked extent. The construction of depth charges, and of their firing mechanisms, was guarded as most secret by the nations employing them, and the United States, as a neutral, was not afforded information concerning them.

Nevertheless, and prior to our own entrance into the war, the Navy Department had realized the necessity of being adequately armed with this new weapon, as a defense and offense against the submarine. The Bureau of Ordnance undertook the development of this weapon and, shortly after the opening of unrestricted submarine warfare, in February, 1917, had passed upon a design and commenced actual manufacture in quantity of an explosive charge of this character, known as a "depth charge." This first design contained 50 pounds of explosive and was operated on the float and line principles; that is, a float which became detached from the charge proper upon strik-

[1] Referring to loss by submarines, Mr. McNamara, on May 8, 1919, in the House of Parliament, stated that during the war merchant shipping to a total of 12,750,000 tons was sunk by enemy action, and out of this tonnage 7,500,000 tons were British.

DEPTH CHARGE OF THE LATEST TYPE, SHOWING DEPTH-SETTING MECHANISM.

96-1

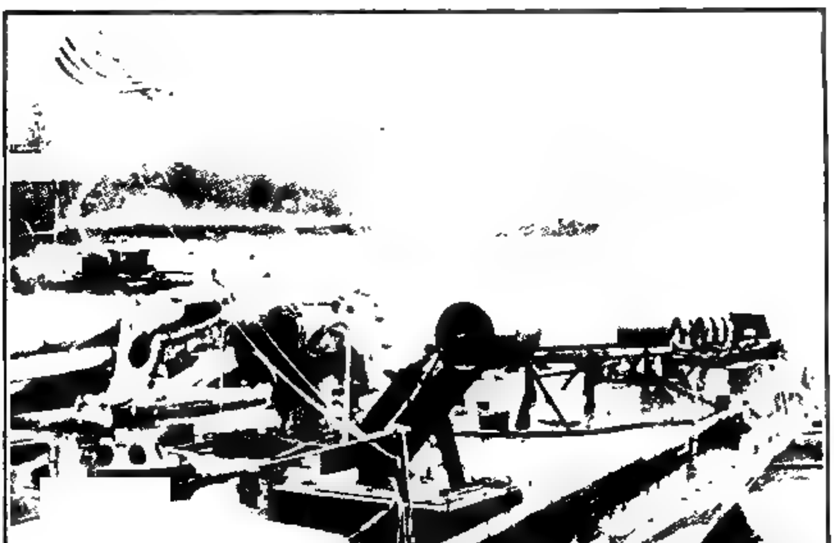
STERN OF A DESTROYER, SHOWING GUN CREW AT STATIONS AND TWO DEPTH CHARGES READY FOR LETTING GO.

This arrangement for launching the "ash cans" was utilized before the development of the depth-charge launching gear.

98-2

STERN OF A U. S. DESTROYER IN A ROUGH SEA.

THE DEPTH-CHARGE EXPLOSION RAISES QUITE A HILL OF WATER AND MAKES IT VERY UNCOMFORTABLE FOR ANY SUBMARINE IN THE VICINITY.



THE QUARTER-DECK OF A DESTROYER, SHOWING A FEW DEPTH CHARGES ON THEIR RACK AND A SINGLE-BARRELED "PROJECTOR" OF THE THORNYCROFT TYPE.

ing the water, and remained on the surface while the charge sank and, in sinking, payed out rope attached to the buoy, which rope eventually fired the charge. By an ingenious device, the depth at which the charge would fire could be instantaneously changed by a ready setting effected on the outside of the charge, without alteration of the length of the rope. This depth was regulated at between 25 and 100 feet. Contracts for 10,000 of these depth charges, known as the Mark I, were placed.

At the entrance of the United States into the war, these charges were almost immediately available for issue to vessels of the United States Navy. It was soon apparent, however, that with the construction of larger and stronger submarines, the 50 pounds of explosive contained in these charges was not sufficient, and the department immediately undertook the development of larger charges. By this time, our new Allies had supplied us with all military information which we desired, and with this was the guarded and valuable knowledge of firing gears of depth charges. Owing to the small charge of our depth charge and the sometimes erratic action of its firing gear, the adoption of the British depth charge *in toto* was urged by the department. This British charge contained 300 pounds of explosive and was actuated by hydrostatic pressure.

The bureau considered that the design submitted to it as being the latest British type was unsafe according to American ideas, and also unreliable, and completed a development of its own. Not until this, its own design, was ready for test did it learn that the mechanism submitted to it, as being the British, had proven unsatisfactory and was being discarded in the British Navy in favor of a new and more reliable type.

Meanwhile, however, the Naval Torpedo Station at Newport had developed a type of hydrostatically operated depth charge, which appeared at least the equal of even the latest British design. This firing mechanism was mainly the work of the Bureau's engineer of mines and explosives, Mr. C. T. Minkler.

Specimens of the new British depth charge were obtained from abroad and samples of the Newport design were manufactured, and comparative tests carried out at Newport by the experimental officer of the bureau, Lieut. Commander T. S. Wilkinson. These comparative tests demonstrated, in the opinion of our naval officers, the superiority of the American type over the British, both old and new. The difference lay only in the firing gear, as we had adopted without question the explosive weight of 300 pounds and the external cylindrical container of the British type. In addition to a heavier charge, a greater range of depth setting had been obtained in the American Mark II depth charge.

Manufacture in quantity of the American depth charge of the Newport design, now known as Mark II, was at once commenced, under the direction of Commander S. P. Fullinwider, and the issue to the service began in the fall of 1917. The first contract for 10,000 of these Mark II depth charges was placed in July, 1917. Later, modifications of the Mark II depth charge were made and contracts for 20,000 more were issued in the spring of 1918. In December, 1917, the bureau placed a contract for 15,000 British type depth charges for the British Government.

Very extensive use of the two types abroad by our destroyers and other vessels has supported the original opinion of our officers, and the American depth charge is now acclaimed by our forces as at least as good as the British in both safety and effectiveness. The British gave new testimony to this fact, in that they borrowed a number of our depth charges for use in their depth charge throwers or projectors, because of premature explosions of their own when fired therefrom.

The American and British depth charges differ in several main particulars. Ours fires by means of hydrostatic pressure, while the British utilize the seepage principle also. Our mechanism is installed inside the container, so as to reduce the likelihood of its damage in handling and service, while the British firing gear case protrudes several inches beyond the head of the cylindrical depth charge case. Our firing mechanism retained the safety chamber principle, which insured that, even should the detonator be fired by accident in transportation or handling, the charge would not be detonated. The explosive we used was TNT, a more powerful material than the amatol used by the British.

The depth charge consists of a cylindrical metal case, approximately 18 inches in diameter and 28 inches long for the 300-pound depth charge, containing the explosive and firing mechanism, or pistol, as it is called. By means of a dial at one end of the case, the depth charge may be set to explode at one of several depths from 50 to 200 feet. When the depth charge reaches the depth at which it is set to explode, the pistol is actuated by the hydrostatic pressure at that depth and explodes the charge.

It became apparent, during the summer of 1918, that very many more depth charges would be required for the antisubmarine campaign. Therefore, contracts were placed in July for 20,000 Mark II–Modification 2 depth charges, in addition to the 20,000 placed in the spring. The Mark II–Modification 2 depth charge contained 300 pounds of explosive, had a total weight of 420 pounds, and a maximum depth setting of 200 feet. It retained the safety features, the mechanism not being in the firing position until the depth charge reached a depth of 15 feet. The rate of sinking was 6 feet per second.

U. S. PATROL BOAT EAGLE 1, SHOWING DEPTH-CHARGE LAUNCHING GEAR AT STERN, "Y" GUN AMIDSHIPS, AND STERN GUN ON DECK HOUSE.

Ammunition boxes may be seen near the port rail and depth charges near the starboard rail.

100-1

THE AFTERDECK OF AN AMERICAN DESTROYER IN THE WAR ZONE.

In the foreground, on top of the twin torpedo tubes, is a life raft with a water breaker in it. Next is the after binnacle and hand-steering wheel, behind which is seen a "Y" gun with two depth charges Abaft this are two tracks filled with "ash cans," ready to be dropped on a Hun submarine.

100-2

About this time, the design of a depth charge providing for a depth setting up to 300 feet, instead of the 200-foot maximum setting of the Mark II, was completed. This depth charge was known as the Mark III. It had the same dimensions and weight as the Mark II–Modification 2. A contract for 10,000 of these Mark III depth charges was placed the latter part of July.

A still larger depth charge than one containing 300 pounds of explosive was thought to be desirable in certain cases. Therefore, the Mark IV depth charge, containing 600 pounds of TNT was designed. This depth charge had the same length as the 300-pound depth charge, but a diameter about 7 inches greater. Its total weight was 745 pounds. One thousand were manufactured. Deliveries on the first contract, which was placed August 1, began about a month later; and the first of these large charges was sent overseas the latter part of September, 1918.

Though the detailed design of the depth charges was frequently improved, the basic design of the original 300-pound depth charge was retained in all subsequent models. The one exception was the design of the Type D–Modification 1, which was a modification of the British type depth charge. This design could be used in shallow water, as it would explode by seepage of water, if the depth was shallower than that for which set. A very small number of these were manufactured just before the armistice and none was used.

There were, in all, six principal contractors for the depth charges. In addition, there were several contractors for small parts, and several subcontractors. The depth charges were shipped to the naval ammunition depots at Iona Island, N. Y., and St. Juliens Creek, Va., for assembly of parts and loading with TNT.

Among the difficulties encountered in the manufacture of depth charges was that of transportation. It was necessary, several times, to ship carloads of them halfway across the continent by express and accompanied by armed guards.

A total of 72,000 United States depth charges were contracted for during the war. When the armistice was signed, a large number of depth charges on the latter contracts had not been manufactured, and cancellations were made as far as possible.

The depth charges were issued to destroyers and other vessels, complete in all respects. In order to make certain that they were all in the best of condition, the depth charges were overhauled, tested, and repaired, if necessary, at the United States Naval Bases at Brest, France, and Queenstown, Ireland.

The depth charge proved a most important weapon in the antisubmarine campaign; and, as experience in its use was gained, its effectiveness was increased. The depth charge has taken its place

along with other naval ordnance, and will be required as long as submarines are employed in war.

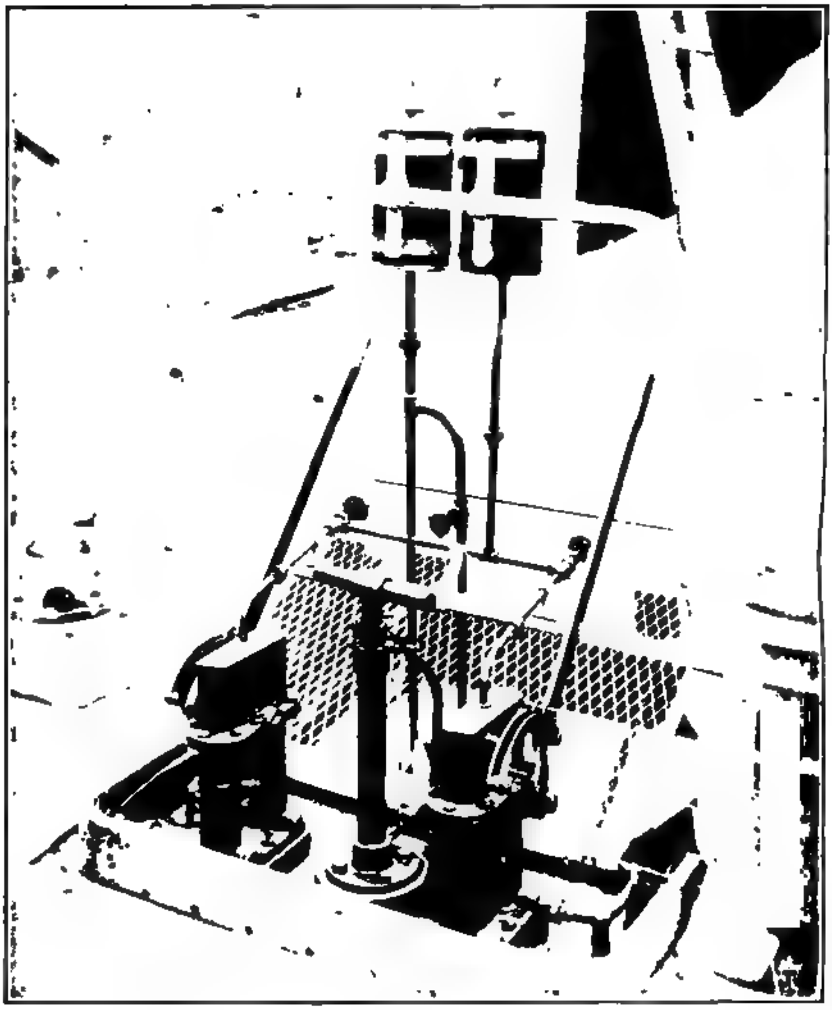
Having developed an effective weapon for attacking submarines under the surface, the next step was to develop means of using these weapons. Depth charge tactics were worked out and put into practice by the destroyers and other craft operating in the submarine zone. Depth charges were used at every opportunity and wherever there was any question of the presence of a submarine. In many instances, the explosion of depth charges brought up oil and other indications that a submarine had been damaged, but only positive sinkings were credited as such in official records.

The bureau by its expedition in the production of depth charges permitted the forces operating against the submarines to use them in greater and yet greater numbers. This enabled tactical uses of the weapon to be scientifically developed, all of which made the submarine's cruising more and more hazardous. Even more charges than the bureau did succeed in getting overseas would have been welcomed, but, nevertheless, the antisubmarine tactics were so changed by the increased supply and became so much more efficient, that the enemy submarine operations were severely curtailed and rendered so hazardous that this factor had a tremendous weight in sounding the knell of the German hopes of success in their submarine war.

At 1.18 p. m., July 13, 1917, while cruising south of Ireland, the U. S. S. *Warrington* sighted an enemy submarine about 4 miles off. The submarine submerged when about 2½ miles off. The *Warrington* proceeded to the place of submergence at full speed, found an oil slick with narrow wake still forming and dropped a depth charge at its end. At 9.30 p. m. a large slick was sighted in the same area, and, 50 yards from its end, the ship struck a submerged object which distinctly lifted the stern of the ship. The ship then turned and dropped two depth charges. This contact was officially classed as having "possibly slightly damaged" the submarine.

On July 30, 1917, at 7.10 a. m., in the approaches to the English Channel, the U. S. S. *Benham* sighted the wake of a periscope, three points forward of port beam, distant 1,500 yards and turned toward it at full speed, at the same time opening fire with the bow gun. *Benham* passed over the wake and let go a depth charge; then turned with full right rudder, opened fire with starboard battery, and passed over wake again and let go second depth charge. The submarine altered course to southeast. *Benham* turned with full right rudder, ran down wake and let go third depth charge. She then turned with full left rudder, ran down wake and let go fourth depth charge, directly over submarine. No further evidence of wake or periscope was

SUBMARINE CAPTURED BY THE FANNING AND NICHOLSON. FORTY-TWO MINUTES AFTER SIGHTING THE PERISCOPE OF THE SUBMARINE THE CREW WERE PRISONERS ON THE FANNING.



DEPTH-CHARGE RELEASING GEAR ON THE BRIDGE OF A DESTROYER, PERMITTING THE RELEASING OF DEPTH CHARGES DIRECTLY FROM THE BRIDGE.

102-3

"PREPAREDNESS" ON A DESTROYER.

At first, when there were not enough depth charges, the destroyers kept two at the stern ready to drop on U-boats. But this scheme was presently enlarged upon until it was not unusual to carry from 20 to 30. The destroyer commander thought nothing of expending all these charges, one after another, on the supposed location of a submarine.

noticed. Bubbles were seen to rise in a large oil slick. This encounter was officially classed as "probably seriously damaged."

On November 17, 1917, the U. S. S. *Fanning*, while escorting a convoy, which was being assembled, sighted a periscope three points on port bow, distant about 400 yards, and heading across the bow at about 2 knots. The *Fanning* was swinging with left rudder, speed about 15 knots, into position covering left rear flank of convoy, about 1,000 yards from the convoy; the U. S. S. *Nicholson* was on her starboard bow standing down from ahead to her position in rear of convoy. The *Fanning's* rudder was put hard left and speed increased to 20 knots, working up rapidly to full power. The periscope disappeared and, when ship had turned about 30 degrees, the rudder was righted and a depth charge was dropped slightly ahead of the estimated position of the submarine. The ship then continued to turn with full left rudder. The *Nicholson* changed course to the right, turned and headed for the spot where the depth charge had been dropped. At about the time her turn was completed, the conning tower of the submarine came to the surface between the *Fanning* and convoy, and about 500 yards from the spot where the charge had been dropped, in a direction toward the convoy. The *Nicholson* headed for the submarine at full speed and the *Fanning* turned into the *Nicholson's* wake to attack. The *Nicholson* dropped a depth charge alongside the submarine and turned to the left, firing three shots from her stern gun while turning. The bow of the submarine then came up rapidly, and it was estimated she was down by the stern at an angle of about 30 degrees and was apparently making about 2 knots. She righted herself and seemed to increase speed to about 5 knots, somewhat down by the head. As the *Nicholson* cleared, the *Fanning* headed for the submarine and opened fire with the bow gun, firing three shots. After the third shot, the crew of the submarine came on deck and held up their hands, and the submarine surrendered. The *Fanning* went alongside to pick up prisoners, the *Nicholson* covering. A line was made fast to the submarine, but apparently at this time she was scuttled, two of the crew disappearing below through the conning tower and remaining below about a minute. She sank, the line was let go, and the crew of the submarine jumped into the water and swam to the *Fanning*. Later information from the officers and crew of the *U-58* shows that the depth charge dropped by the *Fanning* wrecked the motors, diving gear, and oil leads. She then sank to about 200 feet and was entirely unmanageable. She blew tanks and was coming to the surface in an unmanageable condition, when the *Nicholson* dropped a depth charge. The officers reported that the inner hull of the submarine was intact, but that she was wrecked and helpless as stated

above. This action was, naturally, officially recorded under the class of "Known" sunk.

These are only a few of the actions between vessels equipped with depth charges and submarines, and are given here as instances of the use of this very effective weapon.

DEPTH-CHARGE LAUNCHING GEAR.

An important apparatus in the use of depth charges was the depth-charge launching gear, by means of which a number of charges could be carried on the stern of a ship, in position for instant release.

At first depth charges were carried singly in slings on the stern of destroyers; by control levers and an oil-pressure system from the bridge the slings were released and the depth charges dropped. But when the supply of depth charges was increased, the number to be let go in quick succession increased, and a multiple launching system became necessary.

The first multiple depth-charge launching gear, the Mark I, was designed in the bureau in the spring of 1918. It was essentially a track for holding eight depth charges and could be operated either by control from the bridge or by manual control at the track. The design was very rugged, particularly suited to destroyers, and each track weighed about a ton. The first contract for 200 of these gears was placed on March 26, 1918, and deliveries began on April 10. Another contract was placed in June, making the total number ordered 500. As the launching gears were mounted in pairs, this number was sufficient for 250 vessels.

An extension to the track of the launching gear was later designed, which could carry five additional depth charges. With track extensions installed it was possible for a destroyer to carry 26 of the depth charges on board in tracks and ready for dropping. Contracts for 400 of these were placed and about half this number had been delivered when the armistice was signed.

In the latter part of the summer of 1918, a smaller and lighter depth-charge launching gear was designed. One track of this Mark II gear weighed approximately the same as a single depth charge—about 420 pounds—as compared with the weight of a ton of the first gear. The Mark II gear was designed especially for small boats, such as submarine chasers, which were unable to carry the heavy gear first designed. Each track of this gear could carry five depth charges.

A sample Mark II launching gear was built at the Norfolk Navy Yard and found satisfactory in every way when tested. A contract for 1,000 of these gears was therefore placed, but none was manufactured on this contract because of the early ending of the war.

"Y" GUN WITH DEPTH CHARGES IN POSITION READY FOR FIRING

PROJECTILE FOR "Y" GUN, SHOWING DEPTH CHARGE ATTACHED TO ARBOR

In the upper right corner may be seen the base of the "Y" gun casting.

THE "Y" GUN.

To damage seriously a submarine under the surface required that the depth charge explode within approximately 100 feet of her hull, and this, in turn, required fairly accurate knowledge of the location of the submarine, making due allowance for the advance beyond her track on the surface and for the time necessary for the sinking of the charge to the depth for which the index was set. One depth charge properly placed is sufficient to destroy a submarine, but, due to difficulties in locating the submarine, the usual practice was to drop a series of charges at intervals of 10 or 15 seconds, depending upon the speed of the destroyer. This insured damaging the submarine, provided her tracks were sufficiently distinct to enable the destroyer to follow down her wake, and, also, provided that the submarine did not change course. In most cases, however, the submarine changed course as soon as her presence was discovered, and there was no means of knowing her new course and speed, or her location at any moment.

To overcome this difficulty, the British invented and put into service the Thornycroft depth charge thrower, consisting of a single barrel within which fitted an arbor, or stem, to the outer end of which was secured, by adjustable clips or by lashings, the standard British depth charge. This equipment made it possible to throw depth charges out from the side of the ship, in addition to dropping them off the stern, and a sort of barrage was formed, which very much increased the probability of bringing the submarine within the danger zone of a depth charge. Due to the manufacturing difficulties, production of this weapon was slow and limited, and, if destroyers were to be equipped rapidly with depth charge throwers, another type was essential.

Shortly after this country entered the war, the bureau received from the Admiralty photographs and designs of the Thornycroft depth-charge thrower. The possibility of applying the principle of the Davis gun to a depth charge thrower was conceived by Lieut. Commander A. J. Stone, R. F., formerly of the General Ordnance Co., Groton, Conn. The question of the most desirable form of such an apparatus was taken up by him with Mr. L. Y. Spear and then was referred to Mr. G. C. Davison, both officials of this company and graduates of the United States Naval Academy. After making the calculations necessary for the working design, the company undertook the production and tests of the first gun, the order for which was placed with the New London Ship & Engine Co. by the General Ordnance Co.

This Y gun, so called because of its two barrels at an angle of 45° from the vertical, throws two standard 300-pound depth charges at

a time in opposite directions, and destroyers equipped with them were able to produce a barrage of wide pattern, which greatly increased the efficiency of offensive tactics against submarines. By using different sizes of impulse charges, ranges of 50, 66, and 80 yards could be obtained and this feature made variations possible in the pattern of depth charges laid down. The simplicity of this gun made its rapid production possible and no time was lost in placing it into service, where it did splendid work.

The first contract for Y guns was let to the General Ordnance Co., Groton, Conn., on December 8, 1917, but work had been begun on November 24, in advance of the contract, and the first deliveries were made December 10, 1917. Of these guns, 947 were actually put in service. They were installed on destroyers and subchasers, where their use proved their worth quickly. This Y gun was one of the unique and most successful weapons produced in the offensive game against the submarine.

CHAPTER VII.

NORTH SEA BARRAGE, OR NORTHERN BARRAGE.

(THE MARK VI MINE.)

I.—ADOPTION OF THE BARRAGE PROJECT.

The Bureau of Ordnance, even before the United States entered the war, had made a close study of the possible measures to be taken to counteract the submarine peril. It was obviously impossible to consider seriously any proposition to close German harbors, as long as the enemy had complete control of his own waters. The next best plan was to close the North Sea by means of a barrage restricting the operations of enemy submarines to the North Sea, and preventing their getting into the Atlantic and interfering with the lines of communication between the United States and Europe. It was the opinion of the bureau that such a barrage should extend from the east coast of Scotland to the Norwegian coast. This, together with a short barrage across the Dover Straits, would shut off access to the Atlantic, or at least, make the continued operations of enemy submarines exceedingly hazardous and unprofitable.[1] The proposal to construct a barrage 230 miles long was so novel and unprecedented, that it was realized at the time that it would be difficult to obtain a prompt decision to establish it.

Considerable doubt of the success of such an undertaking was expressed in this country; and the British Admiralty, when it was first suggested, believed it almost impracticable. Mine barriers were not considered wholly effective, unless maintained by patrols at all points. Patrols could not be properly protected on such a long line as from Scotland to Norway, because the defense would be stretched out in a long and locally weak line, and, therefore, subject to enemy

[1] It will be easily recalled by those cognizant of the progress of the war that in the fall of 1917 the submarine warfare of the Germans was causing tremendous losses and threatening to prevent the active help of the United States on the Western Front. In fact, in May, 1919, Mr. McNamara stated to the House of Commons that during the war merchant shipping to a total of 12,750,000 tons had been sunk by actions of the enemy, and that out of this tonnage 7,500,000 tons were British.

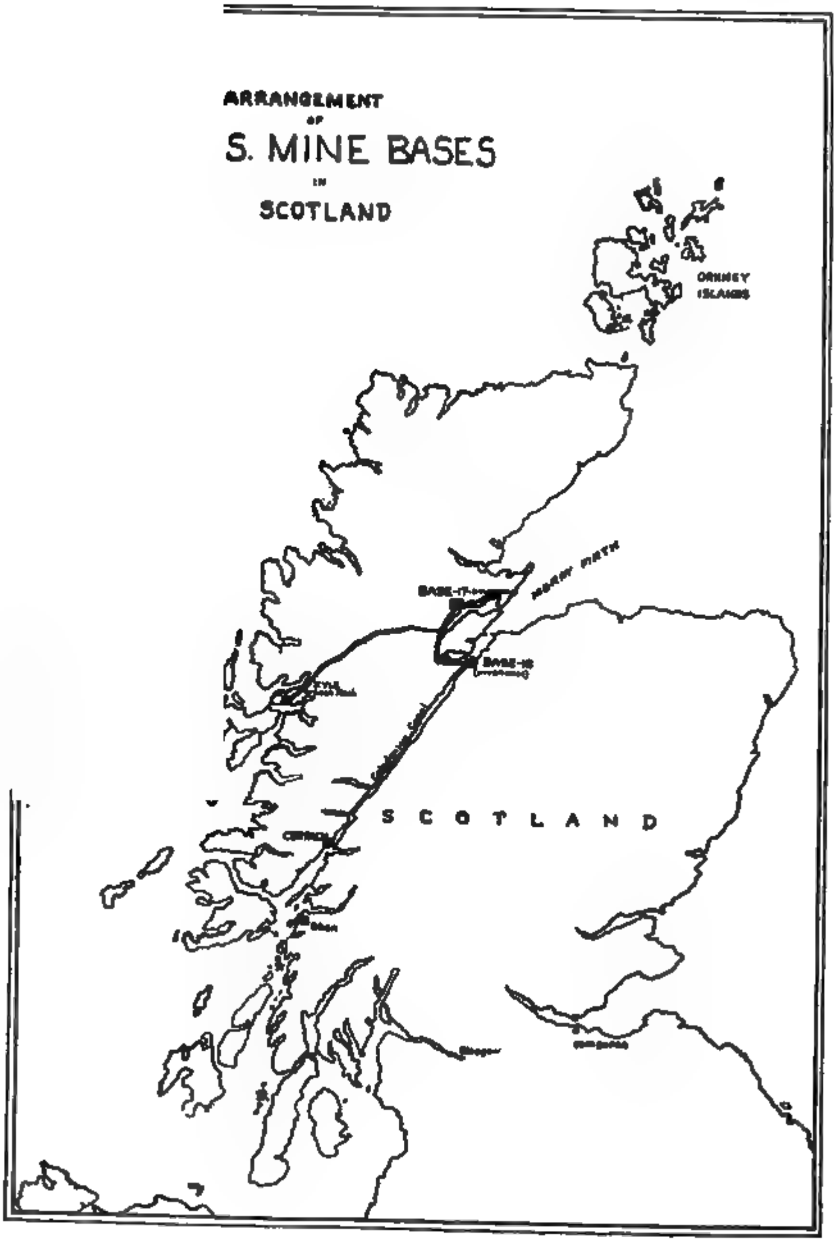
raids in sufficient force to break through the patrol and clear a passage for the submarines. If the patrols were protected with heavy vessels, these would be exposed to the German policy of attrition with torpedo attack. In short, bitter and extensive experience had forced the abandonment by the British of any serious attempt at blockading such passages.

Notwithstanding the unfavorable attitude toward the further consideration of the barrage project, its proponents—that is, the officers of the Bureau of Ordnance—redoubled their efforts to secure its adoption, feeling that the hastening of a favorable issue of the war depended upon it, surely as much as upon any other possible naval measure. While the entrances to the North Sea were very broad, and presented immense difficulties, it was believed that they came within the bounds of possibility of control.

From early in March until the latter part of July, 1917, an intensive study was made in the Bureau of Ordnance by Commander S. P. Fullinwider and his office assistants of many types of barrage, among them the submarine trap and indicator nets which had been used by the British. The majority of the plans considered were devised within the bureau, but in addition a number of inventions and suggestions from private sources were studied. Unfortunately practically all inventions or ideas emanating from nonprofessional sources were based on incomplete knowledge of fundamental conditions and requirements. Their shortcomings may be expressed briefly by saying that they were based on millpond conditions, whereas the waters in which such a barrage as that under consideration had to be planted and maintained were subject not only to very adverse weather conditions but also to the activities of the enemy naval forces, which up to this time had displayed great initiative and resourcefulness.

The types of barrage studied were of three principal classes: First, nets and entanglements; second, nets in combination with mines or bombs; and, third, mines alone. The possibility of employing nets or entanglements alone was abandoned early, inasmuch as the war experience of the British indicated that it was exceedingly difficult to plant and maintain nets of sufficient weight and strength to be of any material value, and because the depth of water in which the proposed barrage would have to be laid was quite prohibitive.

Nets in combination with mines or bombs were open to the same criticism, with the additional point that such material would be very difficult and dangerous to handle, and the planting would be exceedingly slow. It was finally decided that mines offered the only practicable solution, and since no mine then in existence, either in America or abroad, was suitable for the project, mainly owing to the excessive number required, it became necessary for the bureau


ARRANGEMENT
OF
S. MINE BASES
IN
SCOTLAND
ORKNEY ISLANDS
MORAY FIRTH
BASE-17
BASE-18
SCOTLAND

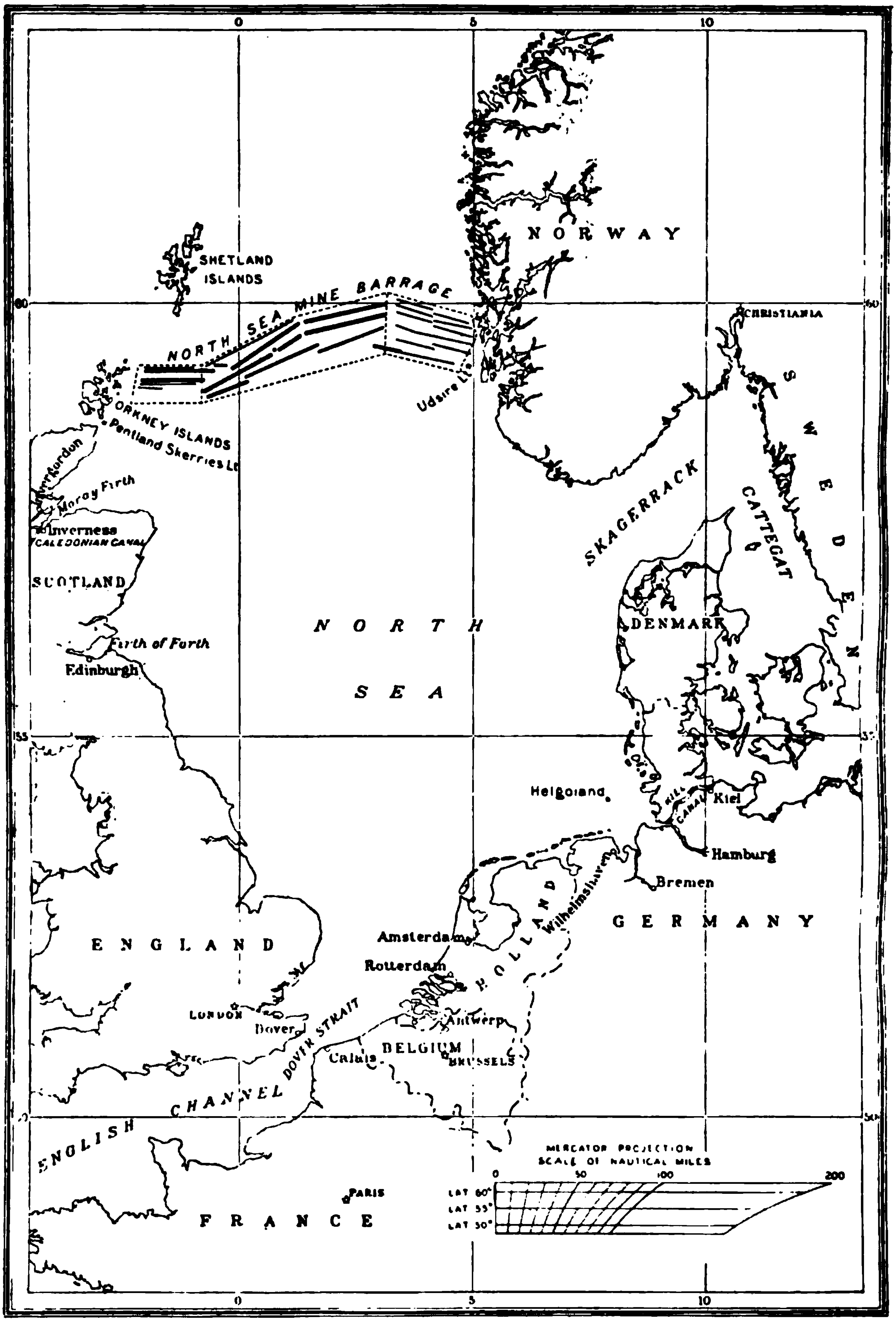


CHART OF THE NORTH SEA, SHOWING THE LOCATION OF THE MINE BARRAGE LAID BY THE AMERICAN AND BRITISH MINING SQUADRONS

108-2

to design a mine especially adapted to the purpose. Such a mine must incorporate many new features, to embody which extensive study, design, and tests were essential. Some of these requirements were quick-loading mine cases; anchors adapted for use in far greater depths of water than any hitherto contemplated and of much greater reliability and ruggedness; an assembly of anchor and mine that permitted their planting as a unit, accurate and at high speeds; a firing device widening the danger zone of each mine; and so on. It was evident that in order to reduce the number of mines required for the barrage a mine should be developed which would explode not only when struck by a submarine, but also when a submarine passed close by.

In May, 1917, development was started on a mine-firing device fulfilling this condition. The successful production of this firing device was primarily the work of Commander S. P. Fullinwider, U. S. Navy (ret.), and Lieut. Commander T. S. Wilkinson, jr., U. S. Navy. The start on the device finally adopted was made immediately pursuant to the suggestion of Mr. Ralph C. Browne, a citizen of Salem, Mass., who submitted an electrical device to be used on what he termed a Browne submerged gun. The officers of the bureau concerned with this, that is, the Chief, Assistant Chief, and Chief of Mines and Net Section, believed the principle could well be adapted to a mine. The inventor of this principle was, therefore, placed in collaboration with the above mentioned officers of the bureau, and Commodore S. J. Brown (Math.), U. S. Navy, with the result that a useful and efficient firing device was produced and tested at New London in June, 1917. During these tests, made on submarines both under way and at anchor, the device functioned in every case. On July 10, further tests were conducted, which determined not only that the principle was sound, but also that there was a satisfactory factor of safety.

The possible disadvantages of this firing device had been taken into consideration. The device would necessarily have to be very sensitive. This sensitiveness might make it possible for the gear to be operated mechanically, as by handling, wave action, or the explosion of an adjacent mine. It might make the gear so delicate that it would become inoperative readily. There was not enough time available for a thorough investigation of the principle of the device, and, in places where the conditions differed from those along the New England coast, there might be something which would cause either spontaneous operation or render the device inoperative. Nothing was known, or could be ascertained in such a short time, as to the effect of continued submergence. Quantity production would inevitably give rise to troubles, which had not been encountered in the

models. New constructions invariably develop faults in service, which can not be predicted.

While the models were being built, and the first tests were being conducted, officers of the bureau studied the situation and came to the conclusion that it was possible to overcome the troubles anticipated, and that while it was impossible without further experience to design a firing gear which would function *perfectly* in the field, it was feasible to produce, before the spring of 1918, one which, at the worst, would give results comparable with those being obtained by other nations and which would be sufficiently good to warrant its use in the barrage. This firing device was, therefore, finally adopted, shortly after the tests at New London.

While this new firing mechanism showed great promise from the first, it was felt to be unwise to place too great reliance on it before it had been thoroughly tested. Therefore, studies of other means of forming a barrage were continued without cessation, until the latter part of July. When the new mechanism had been brought to such a state of development as to warrant its adoption, the bureau decided to abandon all other plans for a barrage and concentrate on a mine embodying this mechanism, which came to be called the Mark VI mine, as it was the sixth type of mine developed by the bureau. The use of this mine reduced the number of mines required for a barrage across the North Sea by two-thirds.

The first tentative plans for a North Sea Barrage were submitted by the bureau to the Chief of Naval Operations, Admiral Benson, on June 12, 1917. The bureau, on July 18, 1917, announced the development of a mine—this Mark VI—peculiarly adaptable for use against submarines; and then, on July 30, 1917, furnished plans for a British-American joint offensive operation involving its use in a barrage across the North Sea. These plans received the approval of the Secretary of the Navy and Admiral Benson, and were then submitted by Admiral Mayo in person to the British Admiralty in late August, 1917.

In September, plans were prepared in the Admiralty for restricting submarines to the North Sea, which were generally in accordance with the original proposition of the Bureau of Ordnance—a barrage between Scotland and Norway, to be a joint British and American operation, and a short barrage across the Dover Straits, to be laid by the British. These plans were sent to the Navy Department and were taken up at a conference on October 15, attended by Admiral Benson, Admiral Mayo, the Chief of Bureau, Commander Fullinwider, and members of the staff of naval operations.

The adoption of the project seemed so certain at this time, that the Chief of the Bureau of Ordnance was, at his request, authorized to

GERMAN MINE OF TYPE PLANTED BY SUBMARINE. RECOVERED BY BRITISH NAVY.

110-1

THE MARK VI MINE FITTED ON ITS ANCHOR

110-2

proceed with the procurement of 100,000 of the new mines, the number which he had estimated would be required.

During the latter part of October it was learned that the British Admiralty had approved the establishment of a mine barrier between Aberdeen, Scotland, and Ekersund, Norway. It had not been possible to go ahead with plans for the barrage, except in the matter of design and manufacture of the mines, until the British decision was definitely known. The project was formally approved by the Secretary of the Navy, shortly after the British approval was confirmed; and, on the following day, October 29, it was favorably acted upon by the President at a Cabinet meeting.

The Bureau of Ordnance at once proceeded with the design and procurement of the required mining material, and the Navy Department undertook all other necessary preparations for the project. The planting of the barrage was to begin as soon as possible in the following spring, 1918, to assure its completion during favorable weather of the summer or early fall. Therefore, there was little time in which to complete the details of the design of the new mines, launch the huge manufacturing project, and obtain production in adequate quantities, not later than February.

Although the Northern Barrage plans, as adopted, provided for the line to extend from Aberdeen to Ekersund, it was later decided to change the location of the barrage, so that it would extend from the Orkney Islands to Bergen, Norway; and it was on this latter line that the barrage was actually laid[1].

This change was really made so that the mind of the Commander in Chief of the Grand Fleet would be free from worry as to mines, in that he could operate anywhere in the North Sea from Scapa southward without passing through the barrier, as would not have been the case had the original line—Aberdeen to Ekersund—been adopted.

II.—DESIGN, MANUFACTURE, AND SHIPMENT OF MINES.

The two principal parts constituting a mine are the mine sphere and the mine anchor, which are held together until dropped from a

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[1] Extract from "The Grand Fleet, 1914–16—Its Creation, Development, and Work," by Admiral Viscount Jellicoe, p. 250:

"In 1917, shortly after my return to the admiralty, I undertook a very extensive mining policy. In the previous year, during Sir Henry Jackson's service as first sea lord, a new and much improved mine was designed, the trials of which were carried out after I relieved him. This was one of the replies to the submarine. One hundred thousand of these mines were ordered by me early in 1917 to carry out various schemes. Later in 1917, with the assistance of the United States, provision was made for the large mine field across the North Sea, known as the Northern Barrage. It was not until the large supplies of mines became available in the autumn that really effective results against submarines by mining began to be achieved, although the operations of German surface vessels had previously been hampered to a very considerable extent."

As a matter of fact, the United States Navy by its insistence and perseverance in the project caused the Northern Barrage to be laid, and for this barrage supplied more than sufficient mines. In fact, of the 70,263 mines laid there were 56,611 planted by the American Mining Squadron, all being American mines.

mine layer. The mine sphere, in addition to containing the explosive charge, comprises all the firing mechanism and the safety arrangements. Contained within the mine anchor, or attached to it, is all the mechanism for mooring the mine. The total weight of the United States type mine and anchor, when assembled, is 1,400 pounds, of which the explosive charge, TNT, is 300 pounds.

At the time the barrage project was finally adopted, the firing mechanism and the mine case were the only parts of the Mark VI mine that had been completely designed. One reason for this was that there was insufficient information with which to proceed with the other points of design, until the firing mechanism was conclusively tested and adopted. Also, until the adoption of the project, there was insufficient personnel in the Mine Section of the bureau for such a large undertaking. The problem confronting the bureau was building a mine around an entirely new principle in mining. This mine had to be efficient, and yet capable of manufacture and assembly in great quantities. The usual mine had been departed from in the new firing gear, and radical developments were then made in the entire mine.

In view of the fact that there were so many uncertainties entering into the design of the mine, it was decided to design it in such a way that modifications of any one feature could be made without detriment to the others. To this end the parts of the mine were divided into groups, each group being quite a separate design problem, and all parts were so standardized that the several groups would assemble into a complete mine. In other words, every precaution was taken against possible loss of time and money. The result was very satisfactory; very few changes were necessary after getting into production, and when the first complete mines were assembled and tested under service conditions they functioned as designed, and only very minor improvements involving no delay in the project were found to be desirable or necessary.

Another reason for following this method of design was that it would facilitate manufacture. There was no plant in the United States that had had experience in the manufacture of mines except the Norfolk Navy Yard, which was overwhelmed with other work after the outbreak of the war and could not be depended upon for any considerable manufacture of mine material. By designing the mine as an assembly proposition it would not be necessary to have it manufactured as a unit, and its many parts could be manufactured in commercial plants with great rapidity. The desired production was 1,000 mines a day, and it was believed that this number could be obtained.

VIEW OF A U. S. MINE ANCHOR, SHOWING THE MOORING CABLE WOUND ON ITS DRUM.

VIEW IN CONTRACTOR'S PLANT, SHOWING NEARLY COMPLETED MINE ANCHORS ON RAILS READY FOR INSPECTION AND ADJUSTMENT.

Secrecy regarding the characteristics of the mine was also preserved by having a large number of plants manufacture the mine. It is obvious that, if 100 different parts of a mine are manufactured by as many different factories, most of which are kept in ignorance of the fact that they are producing mine material, no one will have sufficient information to visualize the complete mine, and, therefore, no one can possibly betray the secret to the enemy. This idea was carried still further. Even at the point of assembly of the material for transshipment abroad the parts were not assembled into a mine but were shipped in groups to the overseas assembly bases. In short, no mines were completely assembled in this country, with the exception of a few for test purposes on board vessels of the mine force. It is therefore believed that the enemy, notwithstanding his many sympathizers in the United States and his secret service, had no inkling of the character of the mine until long after it was placed in use in the North Sea. It was comparatively unimportant to maintain secrecy after the mines were once in use, for it was probable that the enemy could not devise any means of effectively counteracting the mine, or protecting himself against it, within, say, a year after he gained knowledge of it, by which time it was expected that the war would be over.

Another factor entering into the design of the mine was the decision to issue the mines as "fixed ammunition"; that is, to have the mines practically ready to lay when taken aboard the mine layers. It had been the practice in all navies to make numerous tests and adjustments shortly before laying, and this necessitated a large and skilled personnel aboard the mine layer. While this principle of "fixed ammunition" was a radical departure from previous practice it was possible, after it was accepted, to design, manufacture, and inspect the mine accordingly. It is believed that it had much to do with the success of the operation, since, without it, it might not have been possible to prepare the mines rapidly enough to permit of completion of the barrage.

The personnel engaged upon the design of this mine included many officers of the bureau. Initially Commander Fullinwider assumed charge of the design of the mine case and the mine anchor, while Lieut. Commander Wilkinson supervised the designs for firing gear, explosive, and safety arrangements. As the work increased, Commander Fullinwider remained in charge, but distributed the duties of design as follows: To Lieut. Commander O. W. Bagby, United States Navy, and Lieut. S. W. Cook, R. F., the mine anchor; to Lieut. Commander J. A. Schofield, R. F., the mine case; to Lieut. Commander W. A. Corley, United States Navy, the external appliances of the mine case; and, under Lieut. Commander Wilkinson, to

Lieut. Commander C. H. Wright, United States Navy, the firing gear; and to Lieut. (Junior Grade) B. W. Grimes, R. F., the explosive. Lieut. Commander H. E. Fischer, United States Navy, acted as executive assistant to Commander Fullinwider. These officers assumed charge of the particular parts noted, and followed their manufacture in accordance with the general bureau organization plan throughout the stages of production, inspection, and delivery. Lieut. Commanders Bagby and Wright subsequently were ordered to duty at the mine bases abroad.

The actual drafting and detail design work for a large share of the mine parts was done in the bureau's drafting room. The bureau's technical drafting force comprised but three draftsmen, Richard R. Bright, Carl F. Weller, and Charles R. Burr, upon the outbreak of the war. The need of close daily and hourly contact with the bureau's officers and its drafting force, and with the other technical bureaus of the Navy, could not be met by the Naval Gun Factory's design force, and so Lieut. Commander G. L. Smith (ret.) was detailed in charge of the bureau's force, which was augmented quickly to some 31 persons, including experienced ordnance designers. The main portion of the detail drafting and design for ordnance still continued at the gun factory, but the bureau developed mines, mine-firing devices, nets, depth charges, mine anchors, and many other devices.

The Mark VI mine case was formed of two hemispheres of steel welded together at the equator. The firing mechanism was contained in a central tube, extending along the axis of the case. A radical departure from the usual practice was the omission of a separate chamber in the mine case for holding the explosive. The disadvantages of this extra chamber were that it gave additional weight, thus detracting from the buoyancy of the mine; that more time and money were required in manufacture, loading and assembly; and that, most serious, the interposition of an air cushion surrounding the charge chamber, between the first explosive force and the water, greatly reduced the force of the hammer blow caused by the explosion, which is relied on to destroy the vessel firing the mine. These difficulties were obviated by selecting an explosive which could be readily cast and cooled, and casting this directly into the completed mine case. The charge was kept in place by the four stay braces, which supported the central tube; this form of construction permitting of the mine case being kept within comparatively small dimensions, 34 inches in diameter.

The explosive in the Mark VI mine was 300 pounds of trinitrotoluol (TNT). Trinitrotoluol is but slightly inflammable and, if ignited, burns only with difficulty. It is the least sensitive to shock of all known high explosives. This explosive is perfectly im-

permeable to water and, if necessary, could be submerged for years without losing its aptitude of detonation in the least degree. It was for these properties, which make it excellent for submarine mines, that TNT was selected.

The Mark VI mine was designed to be very safe in handling. That this object was attained is well demonstrated by the fact that 85,000 of these mines were shipped abroad and 56,611 of them were planted in the barrage, all without accident.

For instance, a safety point to which careful attention was given was to insure that, in the event of a premature explosion of a mine, it would necessarily occur only after a safe interval after launching. It had previously been the practice to have the detonator—the most sensitive element in a mine—fixed in the explosive. This was a source of danger, in case of accident or fire, or in case the mine layers were engaged in action with mines on board. The Bureau of Ordnance demonstrated by experiments that if the detonator were kept away from the explosive charge the mine would not be fired, if the detonator should accidentally explode, and the only result would be rendering the mine dead, or, in other words, "a dud." With the device adopted for the Mark VI mine, the detonator is not in contact with the main explosive until after the mine has been launched and submerged to a depth of 30 feet. Again, a similar hydrostatic device was incorporated in the firing mechanism, and both of these devices would have to fail to make the mine dangerous on or near the surface.

The necessity for getting the mine anchor into quantity production as soon as possible did not permit of time being taken for development of an entirely new anchor with the necessary experiments. As a result of experimental work carried on since the beginning of the war the British had an automatic anchor (called the Mark VIII sinker) which was giving satisfactory results. It was believed that this anchor could be adapted to the Mark VI mine. The Mark VIII British sinker was, therefore, the basis of the design of the Mark VI anchor, and such modifications were made as were necessary under the direction of Lieut. Commander H. Isherwood, R. N. V. R., an able mine-design officer attached to the bureau through the courtesy of the British Admiralty. The Mark VI anchor differed sufficiently to have warranted thorough tests before its adoption had the time been available. However, as not a day could be lost without correspondingly delaying the execution of the project, it was decided after very careful study of the design that it would be safe to proceed with production. The anchor proved most satisfactory in every respect.

The anchor is a generally rectangular box of steel plate, about 2½ feet square and 2 feet high, and weighs approximately 816 pounds.

The mooring cable, wound on a drum, is contained within the anchor; and a plummet, containing the plummet cord, is hooked on one end.

The action of the anchor, after it is launched, is illustrated. The plummet is released a few seconds after the mine and anchor strike the water; and when it reaches the end of its cord it releases the mine from the anchor. As the anchor descends, the mooring cable unwinds, until the plummet strikes bottom, when the mooring cable drum is locked and no more cable allowed to unwind. The descent of the anchor then causes the mine to be drawn under the water, so that when the anchor rests on the bottom the mine is moored beneath the surface a distance equal to the length of the plummet cord.

Practically all the contracts for the Mark VI mine were placed after competitive bidding. As a result of the keen competition obtained, and also because quantity production was followed throughout, the cost of this mine was far less than that of similar products before the war, notwithstanding the prevailing high cost of labor and material. There were, in all, 140 principal contractors, and over 400 subcontractors.

The first contract placed was for the firing mechanism. The favorable outcome of the proposal for a barrage had been anticipated, and the contract for 100,000 firing devices had been placed on October 3, 1917, nearly a month before the project was definitely adopted. The firing mechanism, while referred to as a unit, was, as a matter of fact, subdivided into its component parts, and manufactured by more than a score of different factories as subcontractors.

The mine case was the next part of the mine to be contracted for, contracts being placed with five companies the latter part of October.

The manufacture of 100,000 mine anchors was such a big proposition that it was decided to call a conference of manufacturers to see if the desired production could be obtained. This conference of manufacturers was held at the bureau November 10, 1917. Representatives of 42 companies were present, all ready and willing—from the larger concerns, anxious to undertake the entire contract, to the small companies desirous of helping by making some of the small parts—to cooperate to the best of their ability. There are over 100 different parts in the anchor, exclusive of bolts, nuts, washers, and rivets. These parts are made from sheet steel, stamped and pressed, forged steel, cast iron, bronze, brass, and even wood. The assembly of all these parts, on a quantity basis, presented a difficult problem. Motor-car makers, of which a number were represented at the conference, are specialists in assembly, as this is one of their chief problems in obtaining quantity production; and it was apparent that they were best fitted for the major contracts, which would include the assembly of all the parts. It is believed that the Bureau

MINE SQUADRON 1 PLANTING MINES SEPTEMBER, 1918.

U. S. S. SAN FRANCISCO, FLAGSHIP OF COMMANDER, MINE SQUADRON_1.

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ENEMY SUBMARINE SIGHTED. ESCORTING DESTROYERS BEGIN A SMOKE SCREEN.

SMOKE SCREEN COMPLETED.

of Ordnance was the first of the war agencies to take advantage of the wonderful resources of the automobile industry.

The Bureau had already decided that it would be inadvisable to place all the work with one concern, not only because of the risk of a complete hold-up due to unforeseen causes but also because such a course was thought necessary to insure the desired speed of production. Contracts for the manufacture of the anchor were therefore placed with three automobile manufacturing companies in Detroit, Mich.

Contracts for various small parts and attachments to the anchor were placed at about the same time as the main anchor contracts. The largest items were wire rope and steel plate. The amount of wire rope required for the mooring cables and plummet-cords was over 50,000,000 feet, and this was divided between nine different wire rope companies. The amount of steel plate required was over 20,000 tons, and this was rolled by six large steel mills.

The majority of the mines were loaded with TNT at the mine-loading plant, St. Juliens Creek, Va. This plant, consisting of 22 buildings, was constructed during the winter of 1917–1918. An important item of preparation for the barrage project was the creation of this complete mine-loading plant capable of receiving, loading, and shipping 1,000 mine cases a day, there being no plant in the United States at that time capable of handling any considerable number of mines.

The design of a plant that could handle the situation was made by the Bureau of Ordnance and the Bureau of Yards and Docks in consultation. Many proposals were sent out in order to obtain ideas upon automatic machinery, and finally a plan, modified somewhat after a scheme suggested by the Boyle-Robertson Construction Co., of Washington, D. C., was accepted and completed. The plant was built by that company; Commander Kirby Smith, Civil Engineer Corps, United States Navy, was responsible for pushing to completion, in the face of many difficulties both in design and construction, this mine-loading plant.

It was decided to locate this plant near the navy yard, Norfolk, Va., the point selected for the assembly and shipment overseas of all barrage material; and a site being immediately available at the naval ammunition depot, St. Juliens Creek, that point was chosen. Ground for the plant was broken on October 25, 1917; but bad weather set in early in November and continued with unprecedented severity until spring, so construction work was carried on under most adverse conditions. Aggravating the situation, there was a labor shortage. However, the plant was ready for work in March, 1918, or practically as soon as needed, there having been delays in

all parts of the project due to extreme weather conditions, freight embargoes, fuel shortages, labor troubles, changes of barrage plan, and so on.

This plant, with its accompanying barracks for the housing of its operatives, covers an area approximately 3,000 feet by 800 feet, including the wharf; and consists of 22 buildings, including a mine case storage building, 600 by 100 feet, capable of storing 5,000 empty cases; a melting plant, capable of melting and pouring TNT for at least 1,000 mines a day; a cooling building, where the loaded mines were permitted to cool preparatory to shipment; a TNT ready storage building, capacity 4,000,000 pounds; a heating plant; and a wharf.

The entire plant was excellently equipped with conveyors and labor-saving facilities; and all parts were planned and constructed to give the utmost efficiency consistent with safety. The rated daily capacity of 1,000 was exceeded by about 50 per cent on one occasion,[1] and a total of more than 73,000 mines, involving the melting and handling of over 22,000,000 pounds of TNT, were loaded here without accident. In addition, 17,000 mines loaded by contract were received here and shipped abroad.

The loading plant cost approximately $400,000, and its operating cost was at the rate of about $412,000 per annum. About 400 enlisted men were required to man the plant; and, in addition, from 200 to 400 were employed in the shipment of mines, that is, in loading them into mine-carrying vessels.

A loading plant of this type and scale had hitherto been unknown, not only in this country, but abroad. Difficulties were encountered in the construction thereof; and prophecies of accident, fortunately unfulfilled, were made by visiting foreign experts skilled in amatol plants. The Bureau of Ordnance, however, took every precaution to insure that the operation of this plant should be attended with the minimum amount of danger. The chief of the bureau took upon himself the limiting of the steam pressure to a maximum which he considered, from his experience with explosives, would result in satisfactory melting of TNT, and thus loading the mines, but reduced the danger of detonation in the process to the minimum possible. Exact knowledge upon this point is not yet to be had, as experience with this explosive has been too short to permit real conclusions. This decision was one that was very serious, as he had before him the fact that, in the melting of high explosives abroad, a

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[1] A test to determine the actual capacity of this mine-loading plant was made on October 9, 1918, when, at 7.57 a. m., the plant commenced pouring TNT continuously, stopping at 7.57 a. m., on October 10, 1918. There were loaded 1,493 mines, or an average of 1.036 mines per minute. The operation of the plant in this instance was considerably hampered, due to the lack of sufficient personnel because of the prevalence of influenza. The plant could have maintained this rate of loading for six and a half days in each week, the remaining half day being necessary to clean up and overhaul machinery.

detonation that destroyed an entire plant together with every person in the same had occurred and that the proposed automatic operation of loading mines was in a nature exactly similar to the work under way in that plant.

Petty officers and enlisted men of the Naval Reserve Force were secured for the operating personnel of this mine-loading plant. They accepted the risk, which they knew was a great one, together with the discomforts—such as working in an atmosphere of TNT dust, working nights, and living in poor quarters in a very bad locality, so far as health is concerned—cheerfully, and with most successful results in the completion of the material for the Northern Barrage.

Commander W. L. Pryor, United States Navy, was in command of this mine-loading plant in addition to his duties in charge of the ammunition depot at St. Juliens Creek. Much work in connection with loading of mines upon the mine carrier, after the TNT had been cast into the mines, devolved upon this officer. The success and general efficiency of the plant was brought about mainly through the untiring efforts and care of Commander Pryor in dealing with the reserve personnel, making them acquainted with the necessity for care and the reasons they were called upon to bear so many discomforts and undergo the risks.

In order to prevent delay in delivery, which might have been caused by delay in completion of this Navy plant, the bureau arranged with the Du Pont Co. to load mines direct at its TNT plant at Barksdale, Wis.; and some 17,000 mines were loaded there during the months of February and March, 1918.

The Army had plainly informed the Navy that it required all the toluol in the country for use in the manufacture of its own explosives; and for this reason, it appeared imperative, if the mine barrage was to be completed, to secure some other explosive for use in the mines. Amatol, a substitute for TNT in general use abroad, had been frequently criticised for lack of effectiveness. Amatol also required more toluol than the Navy could obtain without asking the Army to reduce its requirements. E. I. du Pont de Nemours & Co. proposed to the bureau the use of trinitroxylol, which could be produced by the nitration of xylol, a by-product of coal-tar distillations, at that time not widely used. Further investigation by Lieut. Commander Wilkinson, in collaboration with chemists of E. I. du Pont de Nemours & Co., finally developed the fact that trinitroxylol was an explosive substance which would serve very acceptably as a diluent for TNT, and that the use of a mixture of these two substances in mines would be practically as satisfactory as the use of TNT alone (the mixture adopted consisted of 60 per cent trinitroxylol and 40 per cent of TNT), although the mixture

was not quite as convenient to handle as TNT. Trinitroxylol was subsequently known as TNX; and the mixture of TNT with TNX for mine charges was called toxyl.

Reduction in Army needs, however, allowed the bureau sufficient TNT for the Northern Barrage, and TNX was not used in the mines for this barrage. The manufacture of TNX was pushed, however, and toxyl was to be the filler for the mines for the Ægean and Adriatic barrages, noted later.

The well-known fuel shortage in the winter of 1917–1918, the almost unprecedented severity of the weather, the freight embargoes on the railroad and congestion of traffic generally, and labor troubles, made the situation in regard to the production of mine material very critical for a time, largely because these conditions affected the more than 500 plants engaged, and the failure of any one of them to produce its share would have resulted in possibly disastrous delay to the whole project. During the period of railroad freight congestion, an immense quantity of mine material was handled by express shipments, in some cases whole train loads being handled on passenger schedules from Detroit to the seaboard. It is believed that every known expedient was utilized to maintain production and expedite shipment; armed guards and traffic agents accompanied shipments; motor trucks were used when other service was unavailable; freight embargoes were lifted, after great effort, in special cases; tracing of missing shipments was a constant work; and shortage of fuel was met and overcome in many ways.

In spite of the many difficulties encountered, it was found, soon after getting into production, that the rate of 1,000 mines a day, which had been planned, could easily have been exceeded, if desired.[1] In fact, it became difficult to hold the production of anchors and mine cases down to this figure. In other words, mines could have been produced at any rate desired, except possibly in the matter of mooring cable, the wire-rope manufacturers being heavily burdened with orders for wire for other material.

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[1] British mine record:
- During the entire war produced 300,000 mines, of which—
  - 130,000 laid by British vessels.
  - 15,000 Northern Barrage.
  - 42,000 east coast commanding English Channel.
  - 12,000 Yorkshire.
  - 12,000 other.
  - 8,000 Mediterranean area.
- Output, 10,000 per month.
- 980 firms employed.
- Four-fifths of laying done by British merchantmen.

United States mine record:
- During the war United States produced 102,490 mines.
  - 56,611 were laid in Northern Barrage.
- Output averaged 12,805 per month.
- 540 firms employed.
- All mine laying done by United States naval vessels.

U. S. S. BLACK HAWK, FLAGSHIP OF COMMANDER, U. S. MINE FORCE, AND FORCE REPAIR SHIP.

U. S. S. SHAWMUT.

A TRACK FULL OF MINES READY FOR PLANTING.

MINE SQUADRON 1 LOADED WITH 5,520 MINES EN ROUTE TO THE MINE FIELD.

The mine trials were taken up by the *San Francisco* in March, 1918, when the first mines were ready. Trials were carried out in the lower Chesapeake, later in Narragansett Bay, and finally, off Cape Ann. The results of these trials were all that could be expected. With the exception of a very few minor mechanical faults, which were readily corrected, the mine and anchor functioned as designed. The action of the Bureau of Ordnance, in proceeding with the manufacture of 100,000 mines in advance of such tests, was thus vindicated. A most important result of the trials was the confidence engendered, in the personnel of the Mine Force, in the value and safety of the new mine.

In April, 1918, an additional 25,000 Mark VI mines were contracted for (and practically all completed after the armistice), so that in all 125,000 of the Mark VI mines were manufactured. Development and improvement of the mine was continued, and shortly before the armistice was signed in November, 1918, the manufacture of 25,000 additional mines, known as Mark VI—Modification 1, was in contemplation. These mines were intended for additional barrages, but on account of the ending of the war none was manufactured, such contracts as had been placed being canceled before production had commenced.

In order to ship the enormous amount of mine material abroad, it was necessary to have a large export pier. Accordingly, the Southern Railway Pier No. 4, at Pinners Point, Va., one of the largest export terminal piers in the Hampton Roads district, was taken over. This pier was admirable for the work to be performed.

All parts of the mine were shipped from the contractors to this pier, except the explosive parts. The loaded mine cases, on account of the nearness of the city of Norfolk to the pier, were placed aboard the mine carriers at the mine-loading plant, St. Juliens Creek, Va., following the loading of the mine carriers at Pinner's Point.

Pier No. 4 was used for storage, as well as for shipment. A building on the pier provided storage for 40,000 mine anchors, and small parts were stored in a warehouse near the pier.

While much of the material, such as anchors and plummets (the assembly of the small parts of which was done at the plant of the principal contractor) was shipped abroad as received, some assembly of parts into units was done at the ordnance assembly shop, which was established on Pier 4 for the purpose, and was in charge of a representative of the Bureau of Ordnance, Lieut. A. J. Love, R. F.

The mines were shipped disassembled, not only to preserve secrecy, as mentioned elsewhere, but also to economize space. The handling and inspection at the overseas bases was also facilitated by the mines being received disassembled.

The mine carriers were 23 cargo vessels allocated at the inception of the project to the Navy Department for exclusive use as mine carriers. These vessels were small (about 3,000 tons capacity), having been built for service on the Great Lakes, but were better suited to the purpose than larger vessels. Because of their light draft, the cargoes could be loaded and unloaded at the terminals selected more expeditiously, and it was also desirable to have a comparatively small amount of mine material on any one vessel, so that in case of the loss of a cargo by the sinking of a ship, the effect on the project would not be so serious.

The Bureau of Ordnance arranged with the Naval Overseas Transportation Service for all the sailings of carriers. It was endeavored from the first to make each cargo consist of mine parts for about 1,500 complete units. After the mine material was loaded various commodities awaiting shipment to the bases or to the mine force were used to fill in the interstices.

As many as four carriers were loaded at one time at Pier No. 4, and seven could have been taken care of if necessary. The work was carried on at both Pinner's Point and St. Julien's Creek for 24 hours a day when required. One ship was completely loaded in the record time of 22 hours.

The sailings of mine carriers averaged two ships about every seven or eight days, the time taken to make the trip across being 20 or 21 days. But one of these vessels became a victim to German submarines—the *Lake Moor*—sunk on April 11, 1918.

III.—THE MINE BASES AND MINE PLANTING.

Two advanced mine bases, for the inspection and assembly of the Mark VI mines, were established on the eastern coast of Scotland. The larger base was at Invergordon, and the other at Inverness, 25 miles distant by water. The buildings were furnished by the British Admiralty; but extensive alterations were necessary and railways had to be built. The United States national ensign was officially hoisted over these bases in February, 1918.

The officer in command of these bases, Capt. O. G. Murfin, U. S. Navy, was a representative of the Bureau of Ordnance, under the commander of the United States naval forces in European waters; and he, as well as the several officers sent to assist him, had been trained in the bureau in the assembly and handling of mines. Officers and men reported for duty at the bases from time to time, until on March 30, 1918, the total personnel numbered 814. Much of the work of providing cranes, other equipment and supplies for bases was initiated and pushed by Commander G. C. Schafer, Supply Corps, working with the bureau.

The first mine carriers, bringing mine material, arrived at the bases the first part of April, 1918. Assembly began soon after.

The work of assembling the mines was a highly organized process, developed in accordance with the present standards of manufacturing efficiency. The various component parts were inspected separately before assembly. In the assembly process, the two major parts—the mine case and anchor—moved along on small trucks on rails, the various minor parts being assembled progressively, to a point where the mine and anchor were joined together, and the unit finally tested. The complete mines were then placed in the "ready-for-issue" sheds, or delivered directly to the mine layers. This system, under which separate groups of men, highly specialized, performed the same function for each mine or mine anchor, proved most efficient and produced results never before attained in the rapid handling of mines. The original estimate for the assembly and inspection of mines at the two bases was 500 a day, but the actual rate was readily increased to 1,340 a day. This rate of assembly, taken together with the fact that the rate of mine planting also greatly exceeded the original expectations, made it necessary to change the rate of shipment of mines from 3,500 a week, the number first estimated, to 6,000 a week.

Before the decision to proceed with the North Sea barrage project, the mine force of the United States Navy consisted of only two mine layers, the *San Francisco* and *Baltimore*.

These vessels had a combined capacity of only 350 mines. It was necessary, therefore, to create practically a complete new mine squadron to secure the requisite capacity. Vessels were desired of ample size, yet handy in tactical formation; in serviceable condition as to engines, boilers, pumps, etc.; with good cargo-handling equipment adaptable for handling mines; internal arrangement suitable for installation of mine tracks on two or three decks; speed of 14 to 20 knots; and generally seaworthy. From data on file in the Navy Department it was found that four vessels of the Morgan Line, running between New York, New Orleans, and Galveston, were generally satisfactory for the purpose. They had been built by the Newport News Shipbuilding Co. to replace vessels of the *Prairie* class, purchased by the United States Navy in the Spanish-American War, and were in good condition. They were 391 feet long, 48 beam, and 20 feet draft when loaded as mine planters. They were capable of a sustained sea speed of 14.5 knots and had ample bunker capacity. Their capacity was estimated at 800 to 850 mines each.

The steamship *El Dia*, of the Morgan Line, renamed *Roanoke*, was delivered November 16, 1917, at Tietjan & Lang's shipyard, Hoboken, N. J., where the work of conversion into a mine planter was promptly undertaken. *El Rio*, renamed *Housatonic*, followed at the

same yard November 25; and *El Siglo* and *El Cid*, becoming the *Canandaigua* and *Canonicus*, respectively, arrived at the Morse shipyard, South Brooklyn, November 22 and 24.

Some high-speed vessels were desired for the mine force, but there were few such vessels under the American flag. On the Atlantic coast there were only three of suitable size and build, one of which, the *Old Colony*, had been promised to the British Navy. The others were the *Massachusetts* and *Bunker Hill*. These last two were taken over by the Navy, were renamed the *Shawmut* and *Aroostook*, and were deliverd at the navy yard, Boston, November 6 and 10, for conversion. These vessels could each carry about 300 mines on one deck. They had a speed of 20 knots but a very short steaming radius, about 2,300 miles at economical speed.

Two more vessels, the *Jefferson* and *Hamilton*, of the Old Dominion Line, plying between New York and Norfolk, were requisitioned by the Navy and taken over December 2 and 6, 1917. They were renamed the *Quinnebaug* and *Saranac*, respectively, and the work of conversion was undertaken at Robbins repair yard, Erie Basin, and James Shewan & Sons' repair yard, both in South Brooklyn. Their speed was about 16.5 to 17 knots and their capacity 600 mines each, carried on two decks.

Rear Admiral Joseph Strauss was selected as the commander of the mine force being in direct charge of all operations ashore as well as afloat. He sailed for England in April, 1918. His flagship was the *Black Hawk*, a vessel acting also as repair vessel for the force. Capt. R. R. Belknap, well fitted by his previous command of the fleet mine force, the *San Francisco* and *Baltimore*, commanded the mining squadron. He had done the work of procuring, fitting out, and organizing the vessels for mine planting.

Thus a total of eight vessels were acquired for conversion into planters, which, with the *San Francisco* and *Baltimore*, formed a squadron of 10, with a total capacity of about 5,500 mines. These mine layers were known as Mine Squadron One.

The mine squadron sailed on May 11, 1918, arriving at the bases in Scotland May 26.

Mine laying in this barrage was a joint British and American operation, the original conception, the plan, and the major portion of the material and facilities having been provided by the Bureau of Ordnance. The first mine field was laid on June 8, 1918, and consisted of 47 miles of the new Mark VI mines planted by the American mine layers.

After this first excursion an authentic report was received that a German submarine, cruising on the surface, had been badly damaged by one of the new mines.

VIEW OF BASE 17. TAKEN FROM A BRITISH AIRSHIP.

CAMOUFLAGED ASSEMBLY SHEDS AT BASE 17.
TAKEN FROM A BRITISH AIRSH P.

HEADQUARTERS OF COMMANDER MINE FORCE, BASE 18, INVERNESS,
SCOTLAND.

ONE OF THE BAYS IN THE ASSEMBLY SHEDS AT BASE 18.

Component parts are brought in at the far end of the bay, becoming completed units by the time they have traversed the length of the shed.

ASSEMBLY SHOPS AND READY ISSUE STORE AT BASE 18.

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There were, in all, 13 excursions of the United States Mine Squadron in the laying of the Northern Barrage, the last operation being completed on October 26, 1918. A complete barrier existed in the sea area allotted to our Navy by July 29. Subsequent mines thickened and reinforced this barrier. The barrier should be likened to a very rough, treacherous stretch of country, whose crossing would be a desperate venture, rather than to a country protected by a single barrier, such as the Great Wall of China, requiring one great effort to cross.

In all, 70,263 mines were laid in this Northern Barrage, 56,611 being of the American type of mines, and being laid by the American squadron. The mine laying was usually done by joint excursions, composed ordinarily of 10 American mine planters and 4 British mine planters. The squadron was convoyed, usually, by a force of British destroyers. The best record of mine planting for one of these excursions was a total of 5,520 mines by the American, and 1,300 by the British, or a total of 6,820 mines planted in four hours, the record number ever laid by a mine-laying force in a single operation. On one day the American mine-laying squadron alone planted a field 73 miles long, which is the record for distance. The U. S. S. *Canonicus*, Captain T. L. Johnson, planted 830 mines in 3½ hours, the best record of the force.

The areas assigned for operations were known as A, B, and C. A was the center of the line, B the end toward the Orkneys, C that toward Norway. Besides mining area A exclusively, the American mining squadron laid 10,400 mines in area B, and 5,980 mines in area C, these last two areas being primarily assigned to the British forces. It will be seen that, in addition to mining the part of the barrage originally assigned the United States force, this squadron laid more mines in the British areas than the British themselves. The mines were laid in several lines common to all areas; i. e., lines in which the mines were dangerous to surface craft and submarines at periscope depth; lines which were dangerous to submarines submerged from 90 to 160 feet; and, again, lines dangerous to submarines from 160 to 240 feet, the estimated greatest depth for submarine-boat operation.

The barrage, when completed, extended from Norwegian territorial waters, Udsire Light, to within 10 miles of the Orkney Islands, the 10-mile passage being heavily patrolled. This distance was 230 miles; the maximum depth of water was 1,100 feet. The width of the barrage varied from 15 to 35 miles and, thus, a submarine crossing was in danger from one to three hours when running on the surface, and twice that time when submerged. With the growth of the barrage, German submarines began to use Norwegian ter-

ritorial waters to reach the open sea. This caused the Norwegian Government to announce its decision to mine Norwegian waters, which had the effect of closing this gap.

In connection with this consideration of the antisubmarine mines, it is interesting to note the statement of a captured German submarine commander, who expressed the opinion that, of all the antisubmarine measures taken, mines were by far the most dreaded by the German submarine personnel, principally because there was nothing to indicate their presence. On account of the great improvements in mines, he said, the former practice of fishing up mines, for conversion into punch bowls for submarine messes, had been entirely abandoned!

With the information at present available, it is certain that six submarines were destroyed in the barrage, and that an equal number were severely damaged. It is considered probable, by the British Admiralty, that the loss of five other submarines, the cause for which can not be definitely proven, is accounted for by this Northern Barrage. In so far as reliable records are obtainable, then, a total of 17 submarines is the toll taken by this mine barrage, in the dark waters of the misty North Sea.

The destruction of but one submarine would have more than justified the expenditure, both in money and material, that this undertaking entailed. A close approximation of its cost is as follows:

"NORTHERN BARRAGE" EXPENDITURES.

(A) Mine production:	
Cost of 56,611 mines completed and planted	$17,472,985.15
Cost of 68,389 mines manufactured or partially manufactured, but not planted	21,108,264.85
Total	38,581,250.00
(B) Mine layers:	
Procuring of—	
Canandaigua	100,000.00
Canonicus	100,000.00
Housatonic	100,000.00
Roanoke	100,000.00
Aroostook	1,350,000.00
Shawmut	1,350,000.00
Saranac	----------
Quinnebaug	----------
Repairs and alterations	9,613,583.15
Operating cost of mine layers	7,636,374.34
Total	20,349,957.49

(C) Mine carriers:	
Repairs and alterations	$2,684,049.61
Operating expenses	5,211,706.87
Total	7,895,756.48
(D) Mine bases:	
Operating expenses at Invergordon	10,502,021.87
Operating expenses at Inverness	2,147,548.47
Total	12,649,570.34
(E) Miscellaneous:	
Rental Southern Railway pier No. 4 and outlying properties	144,224.95
Operating cost of mine loading plant	145,334.36
Operating cost of pier No. 4	83,197.31
Total	372,756.62
Grand total	79,849,290.93

There are certain other items of cost, as yet not totaled, which include the cost of inspection force in the United States, and operating expenses of the bases at Inverness and Invergordon.

The value of shipping, in money lost to the world, because of the submarines, runs over $70,000,000 per month for many months; and this money loss does not take into account in any wise the real loss due to the impossibility of replacing such tonnage during the war. The Northern Barrage then, in blocking in the enemy submarines, was justified by monetary considerations alone.

The Northern Barrage accomplished much toward ending German submarine warfare. The British Navy, after years of endeavor, had succeeded in practically closing the Dover Straits to the passage of submarines, when, almost at the same moment, the completion of the Northern Barrage becoming a fact, the two operations effectually restricted submarines to the North Sea.

The crossing of the Northern Barrage was made slightly more difficult on the surface than beneath, because of the fact that it was well known that a submarine commander would prefer striking the mine when on the surface rather than when submerged. As the presence of mines could be known only in general areas, the danger of this unknown and unfindable peril caused great dread of them. The German commanders had found also that the quality of the Allies' mines had been vastly improved in a manner most unpleasant for them. The morale of the submarine personnel was unequal to the strain thus placed upon it, and a submarine crew mutiny took place, followed by the refusal of the main-fleet crews to go out for a final battle. Then came the armistice and the surrender of the whole

German fleet. The early conclusion of the war was caused largely by the failure of German submarine warfare, which failure was openly admitted as soon as the American and British mine barrage was found to be effective. Without doubt the Northern Barrage was a very considerable factor in the ending of the war, and it may rightly be considered one of the most important naval operations undertaken by the United States.

IV.—ADDITIONAL BARRAGES IN MEDITERRANEAN SEA.

In the fall of 1918 extensive mining in the Mediterranean was in prospect, the larger part of which, in accordance with the decisions of the Allied Naval Council at its fifth meeting, was to be carried out by the United States.

The first mining by the United States was to be the reinforcement of the fixed mine-net barrage in the Adriatic Sea, from Otranto to Fano Island, laid by France and Italy, with successive lines of deep mines. This barrage was 54 miles long, and 8,000 mines were required. An additional barrage across the Adriatic, composed of 22,800 mines provided and laid by the United States, would have been established, probably from Brindisi to Saseno Island. And the United States was to provide and lay the 26,800 mines required for the barrage in the Ægean Sea from Euboea Island to Cape Kanapitza, except for the part of the barrage resting in Turkish territorial waters, which was to be established by Great Britain, since the United States was not at war with Turkey.

As may be seen by reference to the chart, the barrages across the Adriatic would prevent the access to the Mediterranean of enemy submarines based on Austrian ports, and the barrage across the Ægean would prevent the entrance into the Mediterranean of submarines based on Turkish ports. Since very few submarines could come into the Mediterranean from Germany, because of the North Sea and Dover barriers, these barrages would practically stop the submarine warfare in the Mediterranean.

These mining operations to be carried out in the Mediterranean made necessary an American base at a convenient point for the assembly of mines and their issue to the mine layers. Bizerta, Tunis, was selected in October, and Capt. O. G. Murfin proceeded there to establish the base and to command it when it was officially placed in commission. All the early material for the equipment of this base was to be obtained in Europe, principally from United States material on hand, in order to have it ready for operation in the shortest possible time—shipments from the United States to replace such material as might be necessary.

The conclusion of an armistice with Turkey on October 30, 1918, and with Austria on November 3, made the Mediterranean Sea bar-

CANAL QUAY, BASE 18. LOADING ASSEMBLED MINES INTO BARGES PRIOR TO SENDING THEM OUT TO THE SHIPS.

DUMB LIGHTER LOADED WITH ASSEMBLED MINES.

TESTING AND ADJUSTING THE FIRING MECHANISM OF THE MARK VI MINE.

The success of the North Sea barrage was largely dependent on preserving the secrecy of this mechanism.

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rages unnecessary, and they were therefore abandoned. Orders were consequently issued to discontinue all work in connection with the establishment of the base at Bizerta. Further reinforcement of the North Sea barrage was planned at this time, but this also was prevented by the signing of the armistice with Germany on November 11, 1918.

V.—MINE SWEEPING.

Mine laying, like the havoc wrought upon the battle fields by the destruction of property, leaves its effects to be felt after peace is obtained. Thousands upon thousands of mines were laid in European waters, the major portion of the work being concentrated in the Northern Barrage. With the cessation of hostilities and the resumption of free shipping, such mines constitute an ever-present danger to vessels on the seas. Many of them break adrift, and, carried by the wind and tide, often appear in waters which were thought to be clear of mines.

One of the first steps after the armistice was to divide the work of clearing the seas among the various nations involved. At an allied naval conference the United States volunteered to remove all mines they had laid, and arrangements were immediately taken in hand to carry out this work. A method of sweeping the American mine fields in the northern barrage was adopted, and the actual operations of sweeping in the areas between the Orkneys and Norway were commenced extensively early in the year 1919. Unfortunately, there were several casualties to personnel and to vessels. The work is hazardous and accidents of this kind are unpreventable.

Rear Admiral Joseph Strauss, United States Navy, who had commanded our mine force during the mine laying, also directed the entire mine-sweeping operations as commander of our force engaged therein. This mine-sweeping force was made up of 34 mine sweepers, 2 tugs, 2 tenders, 24 subchasers, and 20 British Admiralty trawlers which were turned over to the United States. All of the above vessels belonged to and were manned by the United States Navy.

Kirkwall, Orkney Islands, was selected as the operating base for the mine-sweeping force. The first mine-sweeping expedition was of an experimental nature and took place early in May. The results were somewhat discouraging and delays encountered then were experienced in nearly all the earlier operations. The main causes contributing to these delays were heavy weather, fogs, damages to mine sweepers[1] and sweep material, due principally to mine explosions.

[1] The danger of such accidents was materially reduced by the use of certain electrical equipment for protecting the mine sweepers, first proposed, it is believed, by Ensign Dudley A. Nichols, R. F.

The two most serious accidents were the damaging of the sweeper *Bobolink*, on May 14, and the sinking of the trawler *Richard Bulkeley*, on July 12, 1919. The *Bobolink* was damaged by a mine explosion, killing the commanding officer, Lieut. Frank Bruce, United States Navy. The *Bulkeley* was mined and sunk in 6 minutes, drowning the commanding officer, Commander F. R. King, United States Navy, and six men, and, in addition, injuring two officers. Other mine explosions caused damage to the *Pelican*, *Turkey*, *Osprey*, *Patuxent*, *Oriole*, *Auk*, *Sanderling*, *Rail*, *Eider*, *Curlew*, *Tanager*, *SC-208*, *Lapwing*, *SC-46*, and *SC-38*. Minor damages were sustained by several other subchasers, due to the shock of explosions close aboard.

It was found that, owing to the experience gained by the personnel, the rate of sweeping rapidly increased until a very high standard was reached. The following table shows the average number of mines per day removed on the various operations:

	Mines per day.
Second operation	195
Third operation	221
Fourth operation	630
Fifth operation	1,039
Sixth operation	1,200

It may thus be seen that the rate of sweeping was increased over 600 per cent. The sweeping operations varied in length from 10 to 25 days, and after each operation there followed a short overhaul period.

As the work continued improved methods became possible; and on September 30, 1919, our Navy finished clearing American mines from the zone barred by the Northern Barrage. Notwithstanding the fact that this dangerous work was done in a time of peace, the commander of the mine force stated that he had never during his service in the Navy seen a finer spirit displayed or finer work performed by any body of men than existed in the mine force engaged on this hazardous peace-time work of mine sweeping.

CHAPTER VIII.

INVENTIONS AND RESEARCH.

In the present days of mechanical development, the art of war and the weapons of war progress naturally with the advance of the sciences. During peace times, the arts of war advance abreast or perhaps slightly lag behind the arts of peace. In war, however, the entire scientific thought of a nation is thrown into the perfection of its military weapons. The bureau, to be ready for war, had to be prepared not only to carry out every possible advance in time of peace, but also to make use of the scientific knowledge of the country when placed by war at the service of the Military Establishment.

Such an organization the bureau had at the time of the war. The various sections carried out, in some degree, development in the sciences affecting the weapons of which they were in charge. In addition, however, the bureau contained the Special Board on Naval Ordnance, to digest suggested inventions and improvements, and an experimental section to carry on major experiments and to develop new and non-standard weapons.

A.—SPECIAL BOARD ON NAVAL ORDNANCE.

For many years the bureau has contained within itself a board known as the Special Board on Naval Ordnance for the purpose of considering major questions in ordnance material. This board has always been composed of ranking officers with long ordnance and seagoing experience, well equipped to judge the merits of the material in question, both as to its normal operation and as to the varying conditions to which it might be subjected at sea.

To this board were referred all questions of change of type of standard weapons and all new types of weapons.

The function of this board was purely advisory, its duties being to investigate fully and report upon any matter referred to it for consideration. Naturally it had much to do with the development of new devices and the experimentation connected therewith, its

membership being usually temporarily increased by the chief of section having cognizance of the device or development under consideration.

In its reports the board examined the data at hand, made such calculations as might be necessary and, after careful analysis, made such recommendations to the bureau as it deemed proper. At times it might, on its own initiative, bring to the attention of the bureau certain matters upon which, in its opinion, the bureau should take action.

From the nature of its duties, practically every invention submitted to the bureau by civilian inventors was referred to the board for examination and report. To this class of subjects the board devoted much of its time after the outbreak of the war in 1914, as the bureau was flooded with communications from inventors and enthusiasts, submitting ideas which, each writer was firmly convinced, were destined to bring to a speedy end the conflict then raging.

While a few ideas of value were thus submitted, a very large percentage were absolutely valueless, being founded upon imperfect knowledge of the conditions to be met and the material in use, which had been developed after many years of experimentation and thought. In many cases it was difficult to convince inventors that their devices were neither novel nor useful, and that tests of their inventions would be but useless expenditures of time and money.

On the other hand, the bureau desired that inventors in general might feel assured that such ideas and devices as they cared to submit would be carefully examined and reported upon by a board of officers charged with this specific duty. A feeling of confidence, on the part of the inventors, in the fair-mindedness and accessibility of the bureau was thus engendered, that repaid in a great measure the time spent (sometimes incorrectly called wasted) upon useless examination and investigations.

In the earlier stages of the war, before the United States was involved, the ideas of inventors centered about the aeroplane, the submarine, the torpedo, and the mine. Many designs of aerial bombs and bomb dropping and sighting devices were submitted, as well as nets and guns for protection against aerial attacks. The designs for submarines varied from the one-man submarine to giant submarines, displacing several thousand tons and mounting major caliber guns. Numerous devices for protecting ships against mines and torpedoes were also submitted. It is interesting to note that only one of the aerial bomb designs submitted possessed sufficient merit to warrant development.

None of the means for successfully combating the submarine menace, that were subsequently developed, was even suggested, but the

TESTING SMOKE BOXES AT HINGHAM, MASS.

The great volume of dense smoke given off from a number of these boxes enables a vessel to change course unseen by a chasing submarine and make good her escape.

NIGHT PHOTOGRAPH OF A STAR SHELL BURST.

These projectiles are fired behind the enemy craft, whose silhouette becomes plainly visible.

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basic principle of sound ranging, which was later used successfully on the western front, was set forth briefly but clearly by one writer.

One very valuable device was suggested by Mr. Ralph C. Browne, an electrician of Salem, Mass. As originally submitted, this device was incorporated in the design of a submarine gun, which examination showed to be wholly impracticable. The value of this device for other uses, however, was immediately recognized by the officers of the bureau, and, upon their request and much urging, Mr. Browne collaborated with the bureau's experts in developing into a practical form and adapting the device for use in the mines which were being developed for use in the Northern Barrage.

After the entry of the United States into the war, the board was naturally keenly interested in all devices that had to be developed to combat the submarine menace, which soon reached its most acute stage. It took part in the successful development of efficient depth charges, aerial bombs, mines, nets, and smoke-producing apparatus, each of which devices played its part in combating the submarine activities of the Central Powers.

The board also investigated the ballistics of the German long-range gun, and outlined the characteristics of a similar gun, should the bureau become convinced of the utility of such a weapon.

In 1914, a radical departure in the method of gun construction was brought to the attention of the bureau by Mr. A. H. Emery of Glenbrook, Conn., which, at that time, the bureau was unable to accept. In March, 1917, this method was again presented to the bureau by both Mr. Emery and Prof. P. L. Bridgeman, of Harvard University. The bureau then undertook experimentation in the matter. This method produces initial tension in the outer layers of the gun, and initial compression in the inner layers, by fluid internal pressures, of such magnitude as to stretch tangentially all layers, except the outermost, beyond their elastic limit. This process, known as the radial expansion process, produces the same result as would be obtained by the shrinkage process, applied to a gun consisting of an infinite number of infinitely thin tubes. After thorough investigation and considerable experimentation, the board was convinced of the superiority of this process over the shrinkage process, and recommended its general adoption.

The board also devoted considerable time to the development of new high explosives, as there threatened to be a serious shortage of the raw materials used in the manufacture of the high explosives already developed and adopted.

It is still striving to develop a new motive power for torpedoes, with a view to increasing their range and speed, and is also engaged in a very carefully prepared scheme of experimentation and investigation, intended to discover the causes of dispersion, especially at

long ranges, and thus make possible an increase in the accuracy of naval ordnance.

During the early stages of the war, the special board was composed of Rear Admiral R. R. Ingersoll, United States Navy (ret.), and Commodore S. J. Brown, professor of Mathematics Corps, United States Navy. Later Rear Admiral S. A. Staunton (ret.) and Rear Admiral N. E. Mason (ret.), a former chief of the bureau, Capt. B. B. Bierer, and Capt. J. V. Chase reported for duty on the board. The experimental officer of the bureau, Lieut. Commander T. S. Wilkinson, performed additional duty as member of the board.

B.—EXPERIMENTAL SECTION.

Appreciating that the duties of maintaining a supply of ordnance equipment too often precluded, on the part of the material desks of the bureau, continued attention to experimentation in the development of new weapons, the bureau created an experimental section in July, 1916. This section was initially charged with the development of an antisubmarine aeroplane bomb and of other experimental ammunition.

As the war broke and the problem of the submarine became not merely academic but actual and vital, experimentation was carried on with many types of antisubmarine weapons, such as depth charges, mines, smoke screens, and explosives for mines. The services of naval stations such as the Naval Proving Ground, the Naval Torpedo Station, the Naval Gun Factory, and the several navy yards were utilized in preparing the material for and in carrying out such experimentation. In addition, a number of private and public laboratories, in particular the splendid organization of the American University laboratories of the Bureau of Mines and later under the Chemical Warfare Service, were called upon for assistance.

Some of the experimental developments of the bureau during the period of the war are noted.

The first design of depth charge was developed in February and March, 1917, a contract being let to the Sperry Gyroscope Co. for the production of 10,000 charges of this design. These were soon in production and were issued to the Service shortly after the beginning of the war. This type of depth charge was comparatively small, as it contained only 50 pounds of TNT, and it was later replaced by depth charges with a firing mechanism of a new and dissimilar type, carrying heavier charges, which gave a greater radius of effectiveness. The story of the development of the present type was related in Chapter VI.

A design of floating mine, prepared by the Naval Torpedo Station, Newport, R. I., was perfected and a suitable supply (4,000), manufactured and loaded at that Station, was issued to the Service.

SMOKELESS POWDER FIRED AT NIGHT.

Compare this with the photograph of firing of flashless powder from the same gun.

EXPERIMENTAL FIRING AT NIGHT WITH FLASHLESS POWDER.

This shot gave a small flash, otherwise it would not have recorded on a photographic plate.

The depth charge is essentially a weapon for "hunting" craft or light escort vessels, such as destroyers. It is not suitable, except as a weapon of opportunity, for heavy ships such as battleships, cruisers, troop transports and cargo carriers. Their defense depends upon proper escort, ability to maneuver away from danger, and effective use of gunfire. Therefore, it obviously became necessary to provide their guns with shell which would not ricochet on first impact with the water, but would dive and burst under water, thus giving some measure of effectiveness against a submarine, which might be submerged and showing only a periscope as a point of aim. Experimentation with various types of nonricocheting shell led to the development of the present standard F. N., or flat nose, shell as the best type of nonricocheting shell for use against submerged submarines, and these were supplied for the various calibers of torpedo defense guns.

In May, 1917, the bureau took charge of the preparation of smoke apparatus. The effectiveness of this apparatus had been shown by a number of instances in which vessels, menaced or attacked, had been able to maneuver out of danger behind smoke screens laid between them and the enemy submarines. The bureau secured specifications from the British of their standard type of smoke apparatus and later procured a supply of this apparatus, and issued the same to the service, later in the summer of 1917. This consisted of the smoke funnel, Mark I, employing phosphorus, and the Mark I smoke box. Both of these types are now obsolete, but did good service pending the development of superior types. The bureau issued 300 Mark I smoke funnels and 6,400 Mark I smoke boxes.

From information received from abroad, and from original research by the American University Experiment Station, under the direction of the experimental section, the Mark II smoke funnel and Mark II smoke box, now standard, were developed and issued to the Service. The new smoke apparatus is safer to handle and operate and of greater smoke-producing efficiency than the earlier types. These issues comprised 1,500 Mark II smoke funnels and 9,000 Mark II smoke boxes.

Experimentation carried out with the depth charge thrower known as the Y-gun, a weapon suggested by Mr. A. J. Stone, of the General Ordnance Co., Groton, Conn., led to its adoption for service during the antisubmarine campaign. This, as indicated by its name, is a Y-shaped, double-barreled gun from which two depth charges are projected simultaneously on opposite sides of the ship. By its use, in connection with the usual launching devices at the stern, a vessel can lay a simultaneous barrage of depth charges, capable of damaging a submarine anywhere within the effective area. The bureau issued to various types of vessels 947 Y-guns.

In April, 1917, experimental development of a new type of mine-firing device was begun under the direction of Commander Fullinwider of the Mine Section, with the cooperation of the Experimental Section. This led to the adoption, in the fall of 1917, of the Mark VI mine, which was of a type especially suited for use in an antisubmarine mine barrage. The use of this mine has been described in the chapter on the northern barrage.

The development of aero bombs, begun before the war, was carried on. The Mark III bomb, carrying 50 pounds of explosive, was improved and issued to the Service in the fall of 1917. The development of Mark IV and V aero bombs followed rapidly. The Mark IV and V bombs were similar, except in the amount of explosive charge carried. The Mark IV bomb carried a charge of 120 pounds and the Mark V bomb a charge of 220 pounds. The firing mechanisms of service aero bombs were also improved. A total of 15,000 aero bombs was issued to the Service. The major work in the development of these fuses was performed by Messrs. L. S. and J. S. Clarke, of Ardmore, Pa.

An antiaircraft high explosive shell, with a time detonating fuse therefor, was developed and put into production.

Based initially upon information received from the British Admiralty, illuminating shell, or star shell, for 3-inch, 4-inch, and 5-inch guns were designed and production begun. These shell are capable of being used in the high pressure, high velocity Navy guns and are effective at long ranges.

The first experimentation with these shell was by the Germans in 1886; the French starting in 1902, the British in 1909; the Italians and Belgians in 1910, and the United States in 1912. The problem is a difficult one and a really reliable satisfactory shell for high-powered guns did not exist. Among other experimenters, the Pain Fireworks Co. have labored for six years unsuccessfully. Then, too, some 840 inventors have tried without result. Early in March, 1917, the Bureau of Ordnance started intensive work with the problem. The shells developed and fabricated are quite satisfactory. The naval ordnance plant at Baldwin, Long Island, taken over, together with the company's development work, from the Ordnance Engineering Corporation, of New York, was put in operation entirely for the production of shells of this type.

As illustrating their use, on March 21, 1918, two British and three French destroyers were engaged with a force of German destroyers in the vicinity of Dunkirk. The allied forces were aware of the proximity of the German destroyers because of the latter's fire upon Dunkirk. Steaming toward the Germans, the allied destroyers fired star shell to obtain the range. The Germans then ceased firing and fled, and the night being misty, they were soon

MOVING-PICTURE FILM OF UNDER-WATER EXPLOSION OF A MINE, SHOWING DEVELOPMENT OF WATER COLUMN.

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FRAGMENTATION OF LANDING GUN HIGH EXPLOSIVE PROJECTILE, USING SEMPLE MODIFIED FRANKFORD ARSENAL DETONATING FUSE.

out of sight. They were pursued by the allied force; were later sighted by the use of star shells on the part of allied destroyers; were engaged and routed.

The development of flashless powder for secondary battery guns was initiated during the war, and is still progressing with encouraging results. A flashless charge for night firing has several important advantages. Firing may be conducted without disclosing the position of the ship; and the blinding effect on the ship's own personnel, due to the usual charge of straight smokeless powder, is avoided. This adds to the efficiency of gun pointing, spotting, and navigating.

With the assistance of the American University Experiment Station, signal rockets and grenades were developed for both day and night use, more than 500,000 of which were issued. The day signals contained colored smokes; the night signals colored lights.

The American University Experiment Station also conducted experimentation, under the direction of the experimental section, with various new explosives, submarine recognition signals, submarine marker shell, aeroplane float lights, and other devices of this character.

A plan for decoppering guns, by the introduction of an alloy into the gun chamber, was investigated. Laboratory tests of suitable alloy materials for this purpose were concluded and firing tests undertaken.

The war program of the Army and Navy, together with the needs of the allied powers, made great demands upon the available supply of toluol, which is the basis of TNT, the high explosive most widely used for war purposes. In order to relieve the demand upon toluol, the bureau adopted a new explosive—"trinitroxylol," developed by and submitted to it by E. I. du Pont de Nemours & Co. This explosive, when mixed with TNT, gives a resultant explosive which is practically as efficient for all purposes as is TNT. A contract was placed with the E. I. du Pont de Nemours & Co. for a plant capable of producing 30,000,000 pounds of trinitroxylol or TNX per year. At the time of the signing of the armistice, this plant was in operation and the explosive was being delivered. Shortly after the signing of the armistice, however, the contract was canceled. A very important saving in the country's supply of TNT would have been effected by the production of TNX had the war continued.

The chief of the experimental section acted as the bureau's representative on the National Gas Warfare Board. This board, which was composed of representatives of all departments concerned, initiated comprehensive gas warfare investigations at the American University Experiment Station, under the Bureau of Mines. Throughout the work of this station, first under the Bureau of

Mines and then under the Chemical Warfare Service of the Army, the section retained direction of the Navy work (with the exception of gas-mask work, which was under the direction of the Bureau of Construction and Repair) at that station. A large amount of investigatory work was carried on with noxious gases for naval purposes, leading to important results, which, however, the bureau must for the present regard as confidential.

With the cooperation of the Bureau of Ordnance, the National Research Council formed a committee on explosives investigations. This committee collected much valuable data on explosives, which is available for the information of the bureau and other governmental agencies. The committee was originally composed of a representative of the National Research Council, a representative of the War Industries Board, a representative of the Ordnance Department of the Army, and of the Chief of the Experimental Section as Navy representative.

During the war several officers of the British Navy were attached from time to time to the section for purposes of liaison, namely, Lieut. Commander H. O. Mock, R. N. V. R., Lieut. R. H. de Salis, R. N., and Lieut. Commander J. E. Coates, R. N. V. R.; the first two on mines, the latter on toxic gas work.

CHAPTER IX.

AVIATION ORDNANCE.

An American magazine has named itself "The Flying Age.' While this may perhaps be an exaggeration, the war was in no small degree a flying war. In the Army, aeroplanes served for observation, artillery-fire control, bombing, and myriad other uses. In the Navy dirigibles and seaplanes carried on antisubmarine patrols, bombarded enemy harbor works, and escorted convoys through the dangers of the submarine zone.

With the extensive development of air machines, both heavier and lighter than air, came a crying need for development in their offensive weapons. Machine guns were needed to attack other aeroplanes, larger caliber guns for attacking ships and submarines and naval stations; bombs for use on sea and shore.

This bureau, charged with the armament of naval vessels, assumed naturally the responsibility of arming naval aircraft. Here, just as in the development of depth charges and other antisubmarine weapons, it was necessary not only to secure standard and known weapons, but to develop new weapons suitable for the task, to test these, and then procure and issue a supply to the naval service.

The principal items to be supplied were:

- Machine guns with their sights, mounts, ammunition, and fittings.
- Larger-caliber guns.
- Aero bombs, bomb sights, bomb carrying and releasing gears.
- Torpedoes and launching gear.
- Pyrotechnic signaling devices.
- Training devices.

Two principal types of flying boat were to be armed at the outset, but the number of types of aircraft rapidly increased, and, finally all known types of sea planes, together with several types of land planes and dirigibles, were added to those requiring armament.

Previous to the declaration of hostilities with Germany, there was no subdivision, within the Bureau of Ordnance, exclusively charged with the supervision of aviation ordnance. All work, tests, and ex-

periments in this line, made prior to the war, were in charge of officers of the Gun Mount Section, which, together with the Experimental Section and the Explosives Section, had conducted tests, collected data, and started the development and production of the necessary aviation ordnance material.

Early in the war, the Aviation Ordnance Section was established as a subsidiary of the Gun Mount Section to devote itself exclusively to aviation ordnance. Five officers of the Naval Reserve comprised the newly formed section, under Commander S. C. Rowan, U. S. Navy, of the Gun Mount Section. In March, 1918, the aviation ordnance personnel became a separate section, composed of reserve officers only, under Lieut. Commander A. J. Stone, R. F.; and, at the time of the armistice, the section had grown to one regular officer, Commander A. C. Stott, U. S. Navy, in charge, 24 reserve officers, and 12 enlisted personnel. The war personnel of this section will be found in Appendix II of this publication.

Before October, 1917, Lieut. Commander Stone had been sent abroad to collect data and specimens of foreign aircraft ordnance; and, in December, 1917, he returned to the bureau, with voluminous information and a large quantity of foreign material. This material, including bombs, bomb fuses, and bomb gears, machine guns and mounts, bomb sights, gun sights, and various training and instructional devices, together with many working drawings, was largely obtained from the British Air Forces. Later in the month another officer, Lieut. H. P. Claussen, was sent to France to act as liaison officer, to keep the bureau in touch with foreign practice. This officer was subsequently attached to the staff of Admiral Sims and performed valuable service. He finally returned to the United States in October, 1918.

When the United States entered the war, there was no type of machine gun available for aviation use, either as a fixed gun, firing through the propeller, or as a flexible gun on a mobile mount. The standard Lewis machine gun was proving satisfactory in the Navy and Marine Corps, and the Savage Arms Corporation was instructed to modify it, so that it would be suitable for aviation use. Various changes were made to lighten the gun; air cooling was substituted for the water-cooled radiator, and the size of the magazine was increased from 47 rounds to 97 rounds. With these modifications, manufacture was begun, and deliveries commenced in January, 1918. An adequate supply of these guns has always been available since that date.

This type of gun has worked out very well under service conditions, and no serious troubles have developed. Some trouble was experienced with the shell deflector bag. These bags were too small and were not fastened to the shell chute securely enough, occasionally

U. S. NAVY HYDROPLANE HANGAR.

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9-POUNDER DAVIS GUN AND LEWIS MACHINE GUN ON BOW OF FLYING BOAT.

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DAVIS AND LEWIS GUNS ON BOW OF FLYING BOAT.

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N-1 SEAPLANE. DAVIS AND LEWIS GUNS IN POSITION.

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allowing the empty casings to escape. This was very dangerous, if the gun was in front of the propeller on the plane, as the empty casings would ruin the propeller, with a consequent likelihood of the pilot being struck by fragments of the propeller or by the casings themselves. A new deflector was supplied, which has a much larger bag securely riveted to the chute with a metal distender on the inside.

The Lewis gun not being suitable for fixed gun work in synchronized firing through the propeller, an order was placed in September, 1917, with the Marlin-Rockwell Corp. for 1,000 Marlin aircraft guns, which had proved satisfactory in synchronizing tests at the Marlin-Rockwell plant. When production was commenced on these guns, numerous minor mechanical faults developed, and deliveries were held up until July, 1918, since which time the contract has been completed, and the few guns that have been issued to the naval service have been the subject of favorable report.

A heavy water-cooled Browning machine gun used by the Army was adapted for air use by removing the water jacket and lightening the interior part of the mechanism. It has a firing speed of approximately 1,000 shots per minute and uses either the hemp or the disintegrating metal belt feed. It is suitable either as a flexible or as a fixed gun, synchronized with the engine. The Navy had ordered 100 of these guns from the Army, but they were not put in service before the armistice was signed. The demand for fixed, synchronized guns for naval use has been very small owing to the type of aircraft in use.

For the flexible gun mounts used with Lewis guns, the scarff ring mount, as originated by the British and adopted by the Army, was found satisfactory and accepted as standard. This mount was procured from the Army in adequate quantities and in time to meet the gun production. It became standard equipment for the front cockpit of all flying boats. Mounts for two Lewis guns, and outrigger mounts for the side openings in large flying boat hulls, were designed and produced to meet the production of those boats.

For anti-submarine warfare, the need for a large caliber gun with sufficient power to penetrate the hull plating of a submarine, either on, or slightly below the surface, was strongly felt and the Davis non recoil gun was produced and mounted for that purpose. This gun is a radical departure from previous types of gun, in that the barrel is open at both ends, and is loaded at the center by rotating half of the barrel around an off-set axis. The projectile leaves the front barrel in the usual way, while a rear charge of equal weight is projected from the rear barrel. The force of the explosion of the charge is taken up by the reaction between the projectile and the rear charge, and no recoil force is transmitted to the mount. In the early

form of this gun, a rear charge of bird shot and vaseline is used, while in the later model a steel cartridge case is itself projected to the rear, leaving the bore clear for the next load. Suitable stops prevent the rear barrel being depressed sufficiently to endanger the upper wing of the airplane.

In place of the usual form of sight, a Lewis gun is mounted above the Davis gun barrel, at such an angle that the Lewis gun bullets and the Davis gun shell will strike the water at the same point from the usual height of patrol (about 1,000 feet). In aiming the gun, bursts from the Lewis gun are fired in approaching the target, and the Davis gun is fired when the Lewis gun splashes near the mark—a double trigger facilitates this action.

As an example of the possible value of such a weapon, an incident which occurred off Wexmouth, England, in the latter part of September, 1918, may be cited. A patrolling seaplane sighted a submarine with its periscope exposed and failed to damage it with the two bombs carried by the plane. No reply was received to radio messages sent by the plane and the submarine finally escaped, after remaining near the surface for an hour and a half, probably because her diving rudders had gone out of commission. Had a seaplane armed with a Davis gun been present the destruction of the submarine would have been assured:

The types of large flying boat used for anti-submarine patrol in this country were fitted to carry this gun, but none had been sent abroad up to the time of the armistice.

Development of a 37-mm. automatic cannon, for use both as a motor gun, firing through the hub of the propeller, and as a flexible gun on a mobile mount, was undertaken, as was a 3-inch gun for use in the large type of dirigibles. Samples of foreign aircraft cannon were obtained and tests with them, and with various types of ammunition, were made in cooperation with the Army. None of these had passed the experimental stage at the time of the armistice.

During the months of October and November, 1917, a great deal of time was spent in gathering information as to gun sights, particularly those regularly in use abroad. The two sights which stood out prominently and which seemed most desirable were the Aldis unit sight and the wind vane and ring sight. The latter was particularly adapted for mobile guns and the plan was to employ such sights for mobile guns and the unit sight for fixed guns.

The wind vane sights used abroad were of the so-called Norman pattern and our Army, at this time, was negotiating with contractors to copy this sight. Investigation showed that one contractor in particular had proposed an improvement of the Norman pattern sight, looking toward a more sturdy design and the elimination of lost motion. The bureau immediately encouraged the efforts of this

LOADING THE DAVIS GUN

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LEWIS GUN. TRIPLE MOUNT.

142-2

BOMB AND BOMB-GEAR INSTALLATION ON SMALL FLYING BOAT

DIFFERENT SIZES AND TYPES OF UNITED STATES BOMBS.

142-4

contractor, models were made promptly and tests conducted in December, 1917, and production entered into so that the first shipment of Lewis guns abroad, about February 1, 1918, was accompanied by these new sights. Those sights have been used since with all Lewis guns, with uniform success.

The wind vane sight acts as the fore sight and compensates for the velocity of the bullet due to the movement of the gunner's craft. The rear sight is a so-called ring sight designed to allow for the speed of the enemy craft.

These ring sights, as used abroad and as adopted by the Army, comprised a center peep and a single ring calculated for a 110 miles per hour speed of the enemy. The bureau, however, designed a new ring sight comprising two rings in addition to the center peep, one of these rings being calculated for an enemy speed of 100 miles per hour and the other for an enemy speed of 130 miles per hour, the purpose being to present immediately the proper correction for two prevalent speeds and to present a basis from which to interpolate by judgment. These ring sights were furnished commensurately with the wind vane sights, and wind vane sights of various types were furnished, calculated for different speeds of the gunner's craft, all proving entirely satisfactory in service.

Mr. A. H. Woodward, of the contractor company manufacturing these sights for the bureau, becoming familiar with wind vane sights and their operation, designed a so-called "Universal" wind vane sight, which could be adjusted for any speed of the gunner's craft, within adequate limits, thereby intending to eliminate the necessity of providing a number of sights each calculated for a certain speed. This device was worked up to a point of satisfactory performance, acceptance, and production.

Early in the war it became necessary to take special precautions with the inspection and selection of aircraft ammunition for small arms. A system of grading and packing was established which insured a supply of perfect ammunition for aircraft use. New types of bullets were also required, but as these had been in production for the Allies before this country entered the war, no difficulty was experienced in their procurement.

For some time before the war, the bureau had been experimenting with aeroplane bombs. Two types had been developed, suitable for use against troops. These were intended to be used by aeroplanes supporting or operating with naval landing forces on the enemy coast, the aeroplanes to assist in attack on the defending troops.

As the European war progressed, however, it became apparent that aircraft might well be used not only to observe the movements of submarines but to attack them. Submarines on the surface could be seen from aircraft and to varying depths below the surface, dependent on

the clearness of the water. Aeroplanes should therefore be equipped with bombs which would explode on contact if they struck the submarine on or below the surface. The effect of an explosion under water in the vicinity of a submarine has been noted in the chapter on "Depth charges." Similarly, an aeroplane bomb, if it failed to make a direct hit on a submarine, might yet cause considerable damage by exploding in the water near the submarine. Accordingly, the bombs should, failing a direct hit, be capable of exploding at a given depth in the water, so that every possible chance of injuring the submarine might be utilized. Therefore the bureau, long before the entrance of the United States into the war, had made numerous experiments to develop such a dual action bomb.

In April 1917, although tests had been made toward the developbent of such a weapon, no bombs of a perfectly satisfactory type had been put into production. Ordnance development was limited by the scarcity of aircraft available for testing out the material. The first bombs tested had been apparently satisfactory, but, on the afternoon of November 8, 1916, off Indian Head, Md., Lieuts. (Junior Grade) Luther Welsh and C. K. Bronson, United States Navy, were killed by the premature detonation of a bomb. This led to improvement in safety features, with the result that no recurrence of this accident was experienced with American-made bombs during the war. By September, 1917, two types of bomb were in service, and a third type of larger size was coming into production.

The bomb-carrying capacity of naval planes became greater as various types were developed, and so the sizes of bombs became larger and their destructive radius greater.

Looking for a moment at the progress made by the British and French in this regard, it was found that the former first considered a 65-pound light case bomb of sufficient size for effective use against the first types of enemy submarines used. As the submarine became larger and less vulnerable to weapons of this type, they found it necessary to increase the size of the bomb to 100 pounds, then to 230 pounds. Later in 1918, they developed a successful bomb 520 pounds in weight and in the meantime had constructed large seaworthy flying boats that were able to carry two bombs of this size or four of the 230-pound bombs previously mentioned.

Following, now, the progress made by the French during the war and up to about the first of 1918, it is noted that they, also, had increased their sizes of bombs at about the same rate as the British.

Their first successful bomb weighed 52 kilograms and contained 35 kilograms of melinite. The next larger size weighed 75 kilograms and contained 50 kilograms of melinite. Their latest and largest type was the 150 kilogram type, with about 100 kilograms of the same explosive.

144-1

ENLISTED MEN OF THE INSPECTION FORCE AT WORK ON AIRCRAFT BOMBS.

COMPLETED BOMBS HUNG FOR PAINTING.

BOMB AND BOMB-GEAR INSTALLATION BEFORE WING COVERING IS PUT ON.

FLYING BOAT WITH BOMB GEAR, AND DUMMY BOMB IN POSITION.

144-4

The increased size and power of flying boats, and the developments noted abroad, all pointed to an increase in the size of the bombs to be carried, and the bureau began the production of bombs weighing 163 pounds with 117 pounds of explosive, and 270 pounds with 217 pounds of explosive.

Shortly after this time, bombs following the British 230-pound model were manufactured and issued, and a third size of the American-made bomb of 216-pound weight was produced.

The early forms of fusing mechanism for bombs of American design did not prove entirely satisfactory in service, due to their not standing storage under the climatic conditions experienced and to the insufficient care that could be given them under service conditions, and so various changes were made tending toward improvement.

When the defects in this fuse, unforeseen either by the company or the bureau, were developed in service use the manufacturers, Clarke & Co., of Ardmore, Pa., turned their efforts to the design of a still better fuse, and in a short time had succeeded in devising and manufacturing what the bureau considers the most satisfactory antisubmarine bomb fuse extant.

In this new fuse, the requirements for safety are met by the fact that the booster charge is kept several inches away from the primer until after the bomb has fallen at least 300 feet. During this fall an air-driven propellor screws the detonator and primer caps along a threaded shaft into contact with the booster. While attached to the plane in flight, this propeller is prevented from rotating by suitable stops. In case it is desired to drop the bomb "dead," a stop is allowed to remain in place and to fall with the bomb. For a "live," drop, this stop is removed as the bomb leaves the bomb gear. Production of these fuses was begun as soon as possible, but they were not available for issue to the service prior to signing of the armistice.

British-type fuses for the British design of bombs as procured by the bureau were satisfactory and were supplied with those bombs. They, however, did not contain all the features that fuses for use against submarines should possess.

All of the types of bombs described were used in submarine patrol work in this country, the forces overseas, in accordance with departmental policy, obtaining their bombs from foreign sources.

At the time of the armistice light-case bombs of 520 pounds weight, for attacking submarines, and three sizes of heavy case bombs for attack on ships and shore stations were under development, and have since been completed and tested.

Smaller bombs for use on land type machines, with which the Navy and Marine Corps gradually became concerned, were obtained

from the Army, who were already in production with the several models required.

In March, 1918, what was known as the Northern Bombing Squadron was formed for the purpose of bombing, with land machines, Belgian naval bases occupied by the Germans and used by them as submarine, destroyer, and naval air bases. This work was to be done in conjunction with the British Royal Air Force, which had been effectively bombing these ports throughout the war and which had not only seriously embarrassed the enemy by continual day and night attacks, but was gradually making their positions untenable. To assist the British in these attacks, the American Navy was to bomb by night with Caproni and Handley-Page planes, and by day with the DeH-4 and DeH-9 planes operated by marines.

At the time of the start of this northern bombing project, several thousand of various types of Army bombs were ordered from the Ordnance Department of the War Department. Delay in the manufacturing program necessitated the loading of these bombs by the Navy, and steps were being taken to cover this, when advices from overseas showed that these bombs were unsatisfactory for the Navy's purposes, due to the lack of bomb carriers, and also to the fact that the bomb cases were not sufficiently heavy. The whole program was therefore discarded, and the bombs were turned back to the Army.

In October, 1918, Lieut. Claussen returned from England and France for the purpose of starting production on heavy case land bombs to be used by the above land bombing squadrons. Inasmuch as operations were to be in conjunction with the British, it was decided to produce exact duplicates of British bombs, with a view to making interchangeability of bombs and their components possible.

The following program was laid down and steps taken for its completion:

25,000 112-pound heavy case (28-pounds amatol 40/60.)
10,000 250-pound heavy case (111-pounds amatol 40/60).
5,000 550-pound heavy case (180-pounds amatol 40/60.)

Each of these bombs was to be provided with both a nose and tail fuse and a hanging band for horizontal suspension. The type of nose fuse to be used incorporated a suspension lug, which provided a means of vertical suspension inside the fuselages of Handley-Page and Caproni machines. The same nose and tail fuses could be used, interchangeably, in any of the above bombs.

When hostilities ceased, this program was canceled but 50 each of the 112-pound, 250-pound, and 550-pound bombs were cast at the Naval Gun Factory, in order to carry out tests and to obtain further data on heavy case bombs.

< I BOMB.
FUSES.)

....	161 pounds.
....	96 pounds.
....	37½ inches.
....	12¾ inches.

550-POUND MARK I BOMB.
(MARK I AND II FUSES.)

Weight of case	[illegible] pounds.
Weight of cast TNT charge	190 pounds.
Length	62.4 inches.
Diameter	15 inches.

In order to train observers properly in bombing at a minimum of expense, a subcaliber practice bomb was developed, proving uniformly successful. This bomb has an overall length of 8 inches and weighs less than 3 pounds, and, to obtain a smoke puff on impact with water, an ordinary 10-gauge shotgun shell loaded with 8 drams of black powder is fitted into the bomb. Gears for these bombs were supplied, which could be installed on the regular gears without the necessity of modifications.

The bureau also provided so-called "dummy bombs" of concrete, for training purposes, these dummies being of the same size, shape, and weight, and having the same center of gravity as the actual bomb they represented.

The question of sights for bomb dropping was one which received early and careful consideration. By the middle of the summer of 1917, it became apparent that the best foreign sights were the Wimperis high and low altitude sights, of the so-called trombone type. All sights in use up to this time were open to the same criticism; the mechanism was complicated, none could be used with accuracy during drift, and the accuracy of range, which their complications secured, was lost in line error, to remedy which no provision was made. This line error was particularly manifest in the Navy's large flying boats, where the bomb dropper was forward in the bow, and the pilot in the waist of the boat, where he had no line of vision straight down at the target. Various devices and systems of signaling had been devised to enable the bomber to coach the pilot on to the line of approach to the target, but none was satisfactory.

Lieut. A. H. Boettcher, R. F., and Capt. B. L. Smith, U. S. M. C., undertook the task of developing a sight, which should embody a positive and visual indication to the pilot of the relation between his actual course and the bearing of the target. This took form in the pilot directing sight, Mark I, which was tested and approved in December, 1917, Production was begun at once, and the sight issued to the service.

Early in 1918, information was received from abroad of a new effort by Maj. Wimperis—a "Course-setting sight"—regarded as the best sight produced to date, and permitting bombing, either with or without drift. Full data on this sight was not available, however, until May, 1918, when a British officer arrived in this country with a model.

This model lacked only the pilot directing attachment to complete its many excellent features, and five days after it had arrived the first preliminary design, with that attachment incorporated, was tried in the air with astonishingly good results.

Redesign of the sight was begun at once by Lieut. Boettcher, and by August production began, adequate numbers of these sights hav-

ing since been available. Two modifications, one for high-altitude work and one for use in dirigibles, were later made and issued.

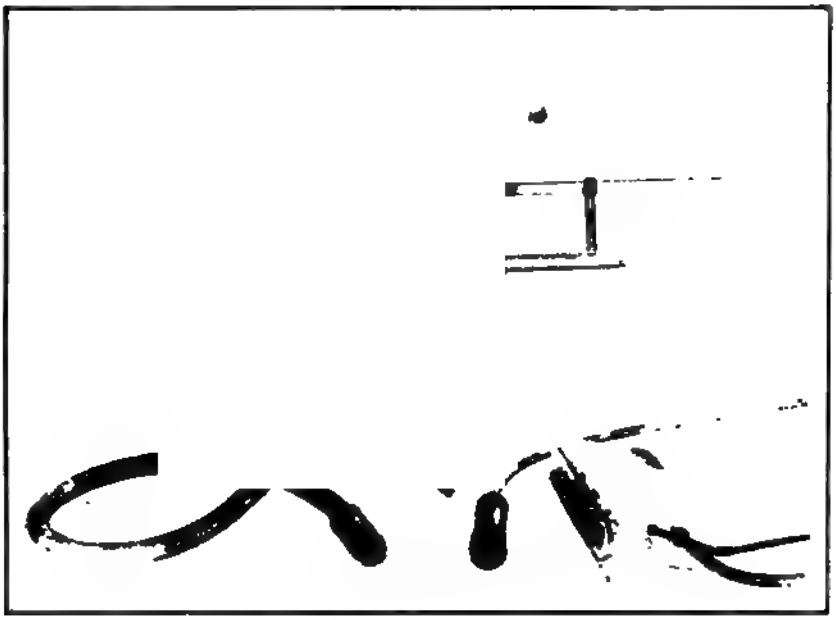
During the war, devices for training the aviation personnel in the use of all forms of aviation ordnance were procured and furnished to the aviation schools in adequate quantities, following generally the lines of foreign practice and experience. The bureau produced one device in particular, the camera gun, which was a great improvement over any known foreign type.

In October, 1917, the Hythe camera gun was the best foreign gun available. It was somewhat clumsy in construction and took but six pictures, one for each pressure on the trigger. In November of the same year, the Eastman Kodak Co. brought out an entirely new camera gun, in which the bureau saw great possibilities and which it assisted the Eastman Kodak Co. to develop. This camera fits the Lewis gun without modifications, taking the place of the magazine, and being actuated by the Lewis gun trigger. It employs standard motion-picture film and takes 97 pictures for one loading of the magazine. Pictures are taken automatically as long as the trigger is depressed, at a rate equal to the rate of fire of a Lewis gun. With this device an accurate record of the results of an aerial combat can be obtained. A later addition provided a time-registering device, whereby the image of a stop-watch hand is shown on the film, thus enabling the time of the first vital shot in a combat to be obtained. Compact outfits, for quick developing of these films, were provided and issued with the camera guns.

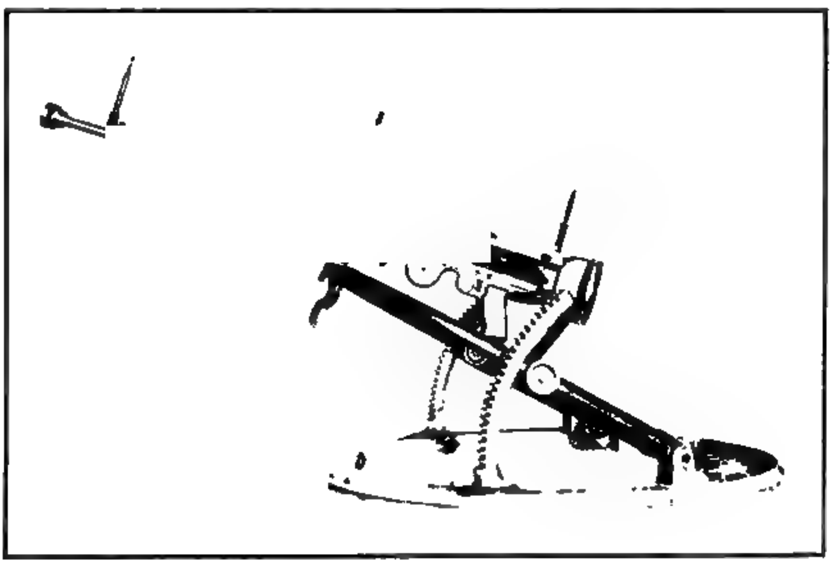
The naval air stations operating in Great Britain, France, and Italy obtained practically all of their ordnance material, with the exception of station guard equipment, from the admiralties of the countries in which they were operating. Technical data was compiled to cover the equipment of various foreign flying corps, and requests were made to the respective governments for the items desired, they being available and shipping facilities from this country being scarce and more urgently required by other war needs.

In order to relieve somewhat the British explosives program, however, 230-pound bombs, which were used by the United States naval air station at Killingholme, were shipped to this country for loading and subsequently returned to that station.

Before and during the war, the bureau kept in close touch with the English and German developments for launching torpedoes from planes in flight, along lines laid down and directed by the bureau since 1914 and similar to those suggested in this country by Rear Admiral B. A. Fiske, U. S. N. (ret.), among others. Experiments and tests were made with various types of aircraft, which led to the equipment of several planes for training purposes and to the design of torpedo carriers to accompany the fleet. The bureau has also



SIDE VIEW OF PILOT DIRECTING BOMB SIGHT ASSEMBLED, SHOWING DETAILS OF CONTACTS.



LEWIS GUN CAMERA ON SCARF RING MOUNT.

PHOTOGRAPHS TAKEN WITH THE GUN CAMERA, SHOWING THE POSITION OF THE CROSS WIRES ON THE ENEMY PLANE AND THE CLOCK TIME.

TORPEDO INSTALLED ON UNDERSIDE OF A SEAPLANE.

SEAPLANE IN FLIGHT WITH TORPEDO READY FOR LAUNCHING.

TORPEDO LAUNCHED FROM A SEAPLANE IN FLIGHT.

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experimented with a system of torpedo launching brought to its attention by the late Mr. Richmond Levering, then major, Chemical Warfare Section, United States Army. This system contemplated the lowering of the torpedo by a thin cable, in such a way that it would be automatically released at a predetermined height above the water.

Preliminary experiments with this scheme gave considerable promise of success; but, in experimenting with a full-sized torpedo, difficulties were encountered which led to the temporary abandonment of the project and to the concentration of the bureau's activities in this direction on the system of launching torpedoes in free flight.

The bureau, in February, 1918, inaugurated an aviation ordnance storehouse at Philadelphia, where, since that time, except for shipments made direct from contractors to aircraft factories and air stations, all aviation ordnance material has been concentrated and from which all shipments were made. Twenty thousand square feet were allotted to this use temporarily, and later, in a new building, 30,000 square feet were allotted. An officer was sent from the bureau to take charge of this storehouse, and the organization, at the time of the armistice, totaled 25, including officers and enlisted personnel technically under the supply officer of the navy yard. Several million dollars' worth of aviation ordnance has passed through this storehouse, and approximately $7,000,000 worth of such ordnance was in stock at the close of hostilities. Facilities are provided there for inspection and repair, so that all shipments may be made in best possible shape.

In the summer of 1918, the bureau inaugurated supertesting and inspection of machine guns, under the supervision of the aviation ordnance storehouse, with excellent results in the way of uniformity in perfect shipments. A concrete firing butt, firing house, and range house were erected, and the supertest and inspection was applied to standard machine guns as well as aircraft guns.

The bureau also inaugurated the system of keeping one of its officers trained in material and in production problems, moving from one contractor's plant to another, to follow up production and assist in expedition wherever possible. It also kept an officer trained in installations, moving from one aircraft factory to another, to follow installations and see that all ordnance equipment was placed in accordance with the bureau's requirements.

Early in the spring of 1918, a pilot, Lieut. A. J. Ditman R. F., was attached to the bureau for experimental work, and made ordnance officer at the naval air station, Anacostia, as additional duty. Most of the experimental work was carried on at Anacostia, much of it in actual flight, and all officers having to do with this work were required to fly. When the facilities at Ana-

costia were not adequate for the purpose in hand, the experimental work was carried on at other air stations, at Hampton Roads, Rockaway, Amityville, Akron, and some of the Army fields, at Indian-Head, and at Dahlgren, and considerable work was done in the shops and in the air at the naval aircraft factory, at Philadelphia. Care was taken to preserve records of all work done, the specially important work being recorded by means of still and moving pictures, to which one officer devoted himself exclusively and for which purpose complete apparatus has been secured and maintained. The bureau has availed itself of these facilities to prepare films for instructional purposes, notably an innovation in the way of moving pictures of submarines afloat, awash, and submerged, so that pilots and observers might acquaint themselves thoroughly with their appearance under these various conditions.

In this connection, it is pertinent to speak of the cooperation of the Army and Navy and of the valuable assistance of the Army in furnishing motion-picture machines and operators and in furnishing instructional films on machine guns.

In general, it should be said that the Army and Navy cooperated efficiently in the matter of exchanging information as to aviation ordnance, in dealing with contractors, in exchanging facilities for tests, and in avoiding duplication of effort wherever possible. Officers of the bureau were in constant touch with the Army officers in their respective subjects, and no stone was left unturned to secure the greatest possible efficiency.

CHAPTER X.

FIRE CONTROL AND OPTICS.

As in the case of many other branches of the Bureau of Ordnance, the war imposed heavy duties upon its fire-control section, which in order to meet these requirements involved great expansion.

The Fire-Control Section was charged with the design, procurement, and manufacture of instruments whereby the fire of the battery is controlled.

Fire control, as understood in naval services, includes the entire system of directing the operation of the offensive weapons of a vessel, including material, personnel, methods, and organization. Its proper development and use is a factor of greatest vital importance to a ship or fleet. When two or more ships are in action both will ordinarily be underway and constantly changing course, speed, or both. The problem, then, is for the ship to obtain and constantly keep the correct range of the enemy vessel and it is the duty of the Fire-Control Section to provide instruments for finding the range, for automatically tracking the enemy, for transmitting such information by electrical means throughout the ship, and to provide the telescopes at the guns.

From a beginning of one officer and one clerk the personnel of this section increased during the war to seven officers, one expert civilian aid, and seven clerks and stenographers.

At the beginning of the war, Commander F. C. Martin was in charge of the section. Commander W. R. Van Auken relieved Commander Martin in July, 1917, and continued in charge of fire-control matters till October, 1918. He was also the bureau's and Navy's representative on the Optical Glass Section of the War Industries Board until relieved of this duty by Commander H. A. Orr. These officers accomplished much in the matter of securing glass for the required instruments and in developing range keeping and other fire-control instruments for the fleet.

When, in October, 1918, Commander Van Auken was detached and ordered to sea, Commander W. R. Furlong reported as his relief. This officer, prior to coming to the bureau, served in the British and

American fleets in European waters and visited the British and French naval stations and returned equipped to take up the new problems of fire control.

FIRE-CONTROL INSTRUMENTS.

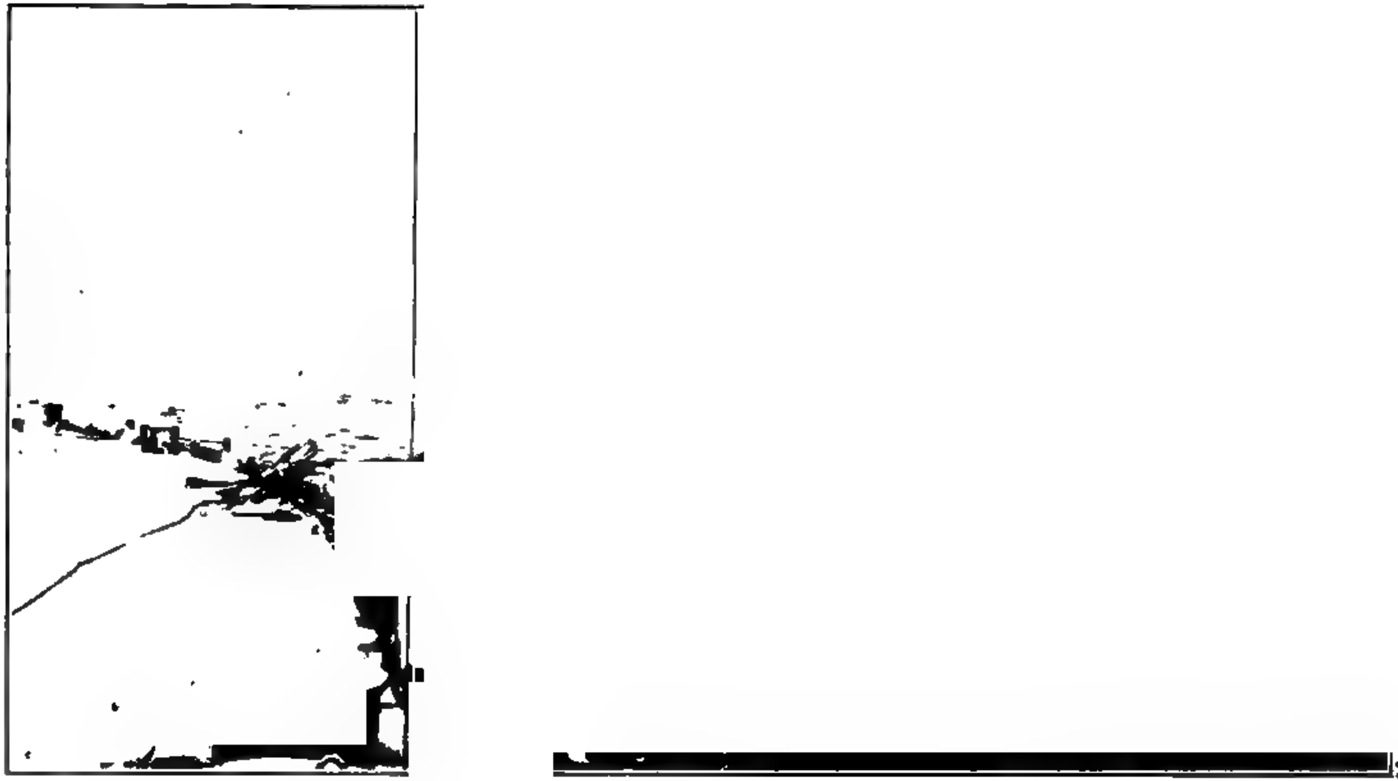
The following table shows the more important instruments which have been developed or the manufacture of which was greatly increased during the continuance of hostilities:

	Total ordered or delivered to Apr. 6, 1917.	Total ordered or delivered to Nov. 11, 1918.	Total ordered or delivered during hostilities.
Alidades, illuminated		12,000	12,000
Battle tracers (Sperry), Mk. I-1 and 2	2	20	18
Destroyer directorscopes		205	205
Ford range keepers, Mk. I and II	9	946	937
Multiple turret indicators	12	33	21
Plotting boards, Mk. II-3		200	200
Plotting indicators, Mk. I-0 and 1	37	55	18
Range and deflection receivers (Cory), Mk. VI		308	308
Range and deflection transmitters		152	152
Range clocks (Vickers), Mk. II	404	404	
Rate of change of range projector, Mk. II	206	206	
Range receivers, electrical, from R. F., Mk. I-0 and 1	12	17	5
Range transmitters, electrical, from R. F. to plot, Mk. I-0	15	17	5
Target bearing transmitters, Mk. I-3, 4, and 5		82	82
Target bearing transmitters, Mk. II-0, 3, and 4		14	14
Target bearing transmitters, Mk. III-0 and 1		14	14
Target bearing transmitters, Mk. IV		30	30
Target turret indicators, single, Mk. III-1		205	205
Target turret indicators, double, Mk. I-0, 1, and 2	29	96	67
Target turret indicators, triple, Mk. I		14	14
Target turret transmitters, Mk. II-1		117	117
Time of flight clocks		278	278
Turret train transmitters, Mk. I-0, 1, and 2	48	169	121
Bearing indicators, Mk. III and Mk. XII-1		128	128

The following table shows the total numbers of the more important kinds of optical instruments, neglecting obsolete types, delivered up to April 6, 1917, together with the corresponding figures for November 11, 1918:

	Apr. 6, 1917.	Nov. 11, 1918.	Delivered during hostilities.
Telescopes	10,176	19,851	9,675
Binoculars	1,490	6,380	4,890
Periscopes	431	543	112
Range finders, short base	234	429	195
Range finders, intermediate base	146	199	53
Range finders, over 25 feet	8	20	12

Thus some conception of the magnitude of the war program, as regards optical equipment for fire-control purposes, may be gained by considering that, between April 6, 1917, and November 11, 1918, the number of range finders actually in service increased 67 per cent; gun-sight telescopes, 95 per cent; and fire-control binoculars, 325 per cent.



SALVO OF 14-INCH PROJECTILES FALLING ASTRADDLE OF A GROUP OF TARGETS TOWED BY A BATTLESHIP.

The firing ship is approximately 20,000 yards on the port beam of the target.

A "SHORT" SALVO OBSERVED FROM A SEAPLANE.

SALVO "STRADDLE," OBSERVED FROM A SEAPLANE. TOWING SHIP IS 400 YARDS FROM TARGET.

SALVO SLICK OBSERVED FROM A SEAPLANE AFTER SPLASHES HAVE SUBSIDED.

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These figures are made more impressive when the condition of the optical manufacturing industry in America prior to 1917 is taken into consideration. America was entirely dependent on foreign producers, chiefly German, for supplies of optical glass, and imported, prior to the outbreak of the Euopean war, considerable quantities of optical parts, such as lenses and prisms, for instruments of high precision. Moreover, the manufacturing capacity, for instruments of relatively low precision, was adequate to meet only a small fraction of the war requirements of the Army and Navy.

It was immediately recognized that the first step in the solution of the optical manufacturing problem was to provide a supply of glass of the necessary high quality for fire-control instruments. The bureau's initial move in this direction was to secure the allotment to the Bureau of Standards, of the Department of Commerce, of a sum of money sufficient to establish an optical glass plant of small capacity but operating on a manufacturing basis. The primary purpose of this plant was to develop processes for the benefit of the industry. This development took place rapidly, and within a few months the regular monthly production exceeded a ton of glass of high quality.

But vastly greater supplies were needed and, as the Nation's war program grew in scope by leaps and bounds, the optical requirements increased in like proportions. The Bausch and Lomb Optical Co. had begun, some years prior to the war, experimentation on a small scale in the production of optical glass. But, early in 1917, it was realized that a plant of large capacity had to be provided, and efficient commercial production secured with a minimum of delay. Accordingly, on the recommendation of the Council of National Defense, the services of the Geophysical Laboratory of the Carnegie Institution were enlisted, and a group of scientists from this laboratory immediately went into this plant to develop the process. By autumn, 1917, such progress had been made that the entire facilities of the enlarged plant were in continuous operation, producing good glass on an efficient manufacturing scale. Moreover, the quality of the product was improving, and continued to improve.

Likewise, at the solicitation of the Council of National Defense, the Pittsburgh Plate Glass Co. undertook, in May, 1917, the manufacture of optical glass. The difficulties encountered by this company were considerable, due to the fact that their factories were not specially designed for the purpose. However, new equipment was provided, the assistance of the Geophysical Laboratory was secured in December, 1917, and a few months later efficient production on a very large scale was in full swing.

The Bureau of Ordnance was vitally interested in and constantly in touch with this commercial production of optical glass. Early in the war it was recognized that the Government should purchase and handle, so far as practicable, a considerable proportion of whatever glass was available for supplying the requirements of those instrument manufacturers who were dependent on outside sources for the glass they required. Accordingly, in the summer of 1917, the bureau took steps to place with the largest manufacturers, the Bausch & Lomb Optical Co., and the Pittsburgh Plate Glass Co., orders for the glass required, so far as the future needs could be calculated. This step had these advantages: The manufacturers were assured a market for a large quantity of glass at a fair price; definite standards of quality were established; and it was made certain that what glass was available would be used only for essential war purposes. In this connection, it is interesting to note that, in general, the manufacture of optical glass has not been an attractive commercial activity, due to the technical difficulties encountered, the limited demands in peace times, and to the fact that the great German factory, the Jena Glass Works of Schott and Genossen, is directly under the patronage of the Prussian Government, and so subsidized as to be able to undersell all competition.

Besides the factories referred to above, the Keuffel & Esser Co., and the Spencer Lens Co. each built and operated optical glass plants, and while the bureau placed no direct contracts for glass with either firm, the product of these establishments was of very material assistance in supplying the needs of the Government and much of their glass found its way into instruments manufactured by or for the bureau.

The solution of the optical glass problem having been well started, the bureau was confronted with difficulties in the manufacture of instruments in the quantities required and of the necessary quality. Large contracts were distributed as seemed wise, and every possible assistance was furnished the manufacturers. Here, again, the problem was complicated by the fact that the requirements were constantly increasing. Very effective efforts were put forth by various firms, particularly the Bausch and Lomb Optical Co., the Keuffel and Esser Co., the Warner and Swasey Co., and the Spencer Lens Co., to increase their output. As a specific instance, mentioned only to show the nature of the changes required by war conditions in many factories, the capacity of the first-named firm was more than doubled, in spite of the difficulties encountered in securing and training skilled help, and the production of nonessential material was reduced to the vanishing point, particularly where this production would hamper that of war material.

BATTLESHIP FIRING A SALVO, AS VIEWED FROM THE AIR.

VIEW OF A BATTLESHIP FROM A HYDROPLANE, SHOWING 12-INCH AND 8-INCH TURRETS.

154—2

BINOCULAR PERISCOPE FOR CONTROL TOWER OF BATTLESHIP.

GUN-SIGHT TELESCOPE WITH CHECKING EYEPIECE.

In December, 1917, it became necessary, in order to meet the binocular situation, for the bureau to take over the plant of the Crown Optical Co. of Rochester, N. Y., the factory becoming the optical shop annex of the Naval Gun Factory. At that time the company had on its books orders for 40,000 pairs of binoculars for the Bureaus of Navigation and Ordnance of the Navy Department, and for 20,000 pairs for the Signal Corps of the Army. Up to the time the factory was taken over by the Navy and placed under the able management of Lieut. Commander L. C. Scheibla, United States Navy, the difficulties encountered by the company had caused serious interference with deliveries. When operations were begun under the bureau, the factory was reorganized, additional space was secured, the number of employees gradually increased, and the weekly production of satisfactory binoculars mounted from practically nothing to a total of some 1,600 by October, 1918. In fact the increase in the production rate was so satisfactory that the bureau felt justified in accepting orders for an additional 37,000 binoculars from the Bureau of Navigation of the Navy Department, and for 75,000 from the War Department. The need for 50,000 of this latter quantity, for which an order was placed in May, 1918, was so urgent that the capacity of the plant was doubled in the summer and it was anticipated that had not production been curtailed after the signing of the armistice the production would have reached 10,000 glasses per month by February, 1919.

In July, 1918, in order to increase the production of instruments, particularly those of high precision, and to enlarge the facilities for the repair and maintenance of all types of optical instruments, construction of the new optical shop at the Naval Gun Factory, Washington, D. C., was started. Equipment was procured, a small force of skilled workers was assembled, and the plant was soon in operation, the Optical Shop Annex, of Rochester, N. Y., having been merged with this new Optical Shop. In connection with this new shop there was established at the Naval Gun Factory an optical design section, with a competent staff of designers and men having had the necessary theoretical optical training.

As the requirements for all sorts of optical equipment increased during hostilities, it was seen to be necessary to centralize control of the optical industry, in order to stimulate production, make wise allocation of orders, and avoid the diversion of labor and material for nonessential purposes. This centralization, which resulted in the organization of the Military Optical Glass and Instrument Section of the War Industries Board, took place in February, 1918, and from that time until the dissolution of the board, this bureau furnished from its staff the representative of the Navy Department in the consideration of matters coming before the optical section.

The chief of the section was assisted by Commander H. A. Orr, U. S. Navy, and by the bureau's expert aid for optics, Mr. Lawrence Radford, in building up the military optical industry of the United States.

Prior to the severing of diplomatic relations with Germany all ships in commission were supplied with the necessary optical gear, with a small percentage of spares. This supply was maintained and the allowance of spares in many cases was increased, but the greater portion of the material procured was used in arming transports and merchant vessels and to supply destroyers commissioned during hostilities.

Prior to the outbreak of the war in 1914, director fire, *i. e.*, firing all guns from one station, had been known in naval services, but had not been recognized as of vital necessity as against pointer fire, wherein each gun is separately layed. The reports of various naval engagements demonstrated the inability of ships using pointer fire to compete with ships provided with director fire and other of the latest improvements. New instruments and methods were being constantly brought out and developed, as the necessities of war demanded, and it is encouraging to note that progress in this respect has been very rapid.

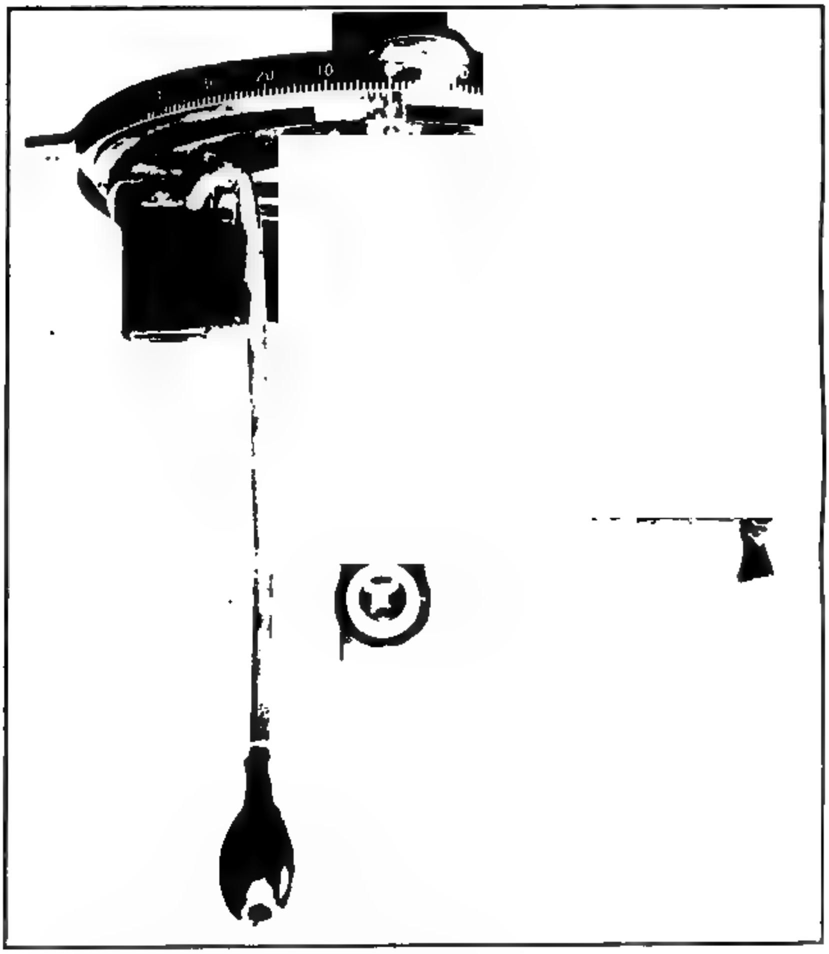
New ships had to have fire-control gear manufactured and ready for supply. Ships built had to be brought up to date rapidly. In this endeavor the bureau cooperated with the manufacturers and very satisfactory results were obtained. The signing of the armistice put a stop to the great rush of work in this connection.

Early in 1916 reports from abroad indicated the necessity of maintaining the sight-bar range by means other than spotting, especially as the use of smoke screens in battle had begun. The Vickers range clock was not effective for this purpose, and Lieut. Commander Martin, then in charge of the Fire-Control Section, discussed the subject with Mr. Hannibal C. Ford, of the Ford Instrument Co. The problem was a difficult one. Numerous conferences followed, with the result that a year later the first Ford range keeper was tested. Modifications found desirable were made from time to time, so that to-day this instrument is considered to be superior to the similar instruments of any of the foreign navies.

Advancement in a "follow the pointer in train" system was rapid. The target-bearing system used before the war was amplified to include a target turret system, whereby the relative bearing of the target, corrected for deflection, is transmitted to the turret. This enables the turrets to fire at an invisible target by simply following a pointer actuated from some control station.

The success of the "follow the pointer in train" system suggested a similar system for elevation. The salient criticism of the train

TARGET-BEARING TRANSMITTER WHICH TRANSMITS THE BEARING
OF THE ENEMY TO PLOTTING ROOM AND GUNS.



TARGET-BEARING TRANSMITTER OF THE TYPE FITTED IN THE CONTROL TOWER BEHIND ARMOR.

The operator is able to see through a periscope projecting through the roof of the tower.

CHANGE OF RANGE PROJECTOR.

TARGET-BEARING INSTRUMENT

system was the synchronization required of the step by step motors. When the elevation system was discussed, all thought was expended toward a design using synchronous motors. About January, 1918, Mr. Ford was called into conference by Commander Van Auken and the manufacture of this system was placed in his hands. In May the first unit, the range converter, was accepted. This was modified as required and in September, 1918, the *New Mexico* obtained the first synchronous follow-the-pointer elevation installation. This Bureau-Ford system is now being installed in all major ships.

With the entrance of the United States into the war all fire-control information held by the British became available to the bureau. One of the first items noted was the need of a follow-the-pointer system in train and elevation for the broadside guns. No American plans were available, so, through the courtesy of the British Admiralty, the British system was adopted. This system is commonly referred to as the Vickers system. The ordnance superintendent of the navy yard, New York, was sent abroad to become familiar with the manufacture of the instruments. Upon his return it was determined to divide the work between the navy yard, New York, the Burke Electric Co., and the Recording & Computing Machine Co.; the first named to build the directors and gun mount attachments, the second the electric motors and transmitters, the third the elevation and training receivers and repeaters.

Lieut. Commander F. S. Craven, U. S. Navy, was sent to Liverpool, England, to the works of Cammell Laird Shipbuilding Corporation in October, 1918, to install a director-firing system on the United States destroyers in European waters. The international situation was such that at the time of his arrival it was evident that the war would soon be over and he did not therefore carry out this duty, but was diverted elsewhere. The system proposed for installation was elementary, consisting of a modification of the directorscope then in use in battleships and simple arrangements at the guns for setting the desired elevation in minutes. The communication of gun elevation was by voice tube and in some cases by Cory range and deflection visuals Mk. VII. Electrical firing from the directorscope was by solenoid at the gun. There was no means for range conversion or for adding in mechanically the director correction.

An instrument for detecting the enemy's course was designed, and 35 of these course detectors are now being manufactured.

Provision was made for more adequate protection for range finders on board ship. For short-base instruments a rubber cover has been designed and submitted to a service test, with very satisfactory results. For range finders of base length of 3 meters or more, mounted

in exposed positions, a design of inclosed mount has been developed which affords complete protection to both instrument and operators. Manufacture of these mounts is proceeding at the navy yard, New York.

Largely at the instigation of the bureau, there was developed by Lieut. Commander A. A. Michelson, R. F., the noted physicist, at the Ryerson Laboratory of the University of Chicago, a new design of long-base range finder, which seems destined to lead to great improvement in such instruments. This design is remarkable for its simplicity and the ease with which repairs may be made, and promises to be free from many of the instrumental errors of range finders now in use. In June, 1918, this work was transferred to Washington, under the direct supervision of the bureau, with the assistance of the Bureau of Standards of the Department of Commerce. In view of the relatively greater need for small than for long base range finders, the same principles were embodied in a 5-foot instrument, with a view to increased production to meet war requirements.

The Bausch & Lomb Optical Co., at the bureau's instigation, have completed designs for a stereoscopic range finder, and for an improved design of 15-foot coincidence range finder, which is intended to be free from some of the variations to which the present instruments are subject.

Due principally to labor troubles, the delivery of instruments on contracts was considerably delayed at first. In addition, lack of material, special machinery, finances, and the loss of experienced engineers by enrollment in the Army, Navy, and Marine Corps, caused considerable inconvenience and delay to the bureau.

The Burke Electric Co., Erie, Pa., manufacturing the electric equipment for the broadside director firing system, was the only firm with which no difficulty was experienced. Their deliveries were as promised, their work perfect. Mr. Burke was especially active in following production. Although he was building equipment in accordance with British plans, numerous suggestions of his were incorporated as changes in the drawings. It is noteworthy that, by the use of a special iron, he produced a torque approximately 25 per cent greater than the sample British motor submitted. Mr. Burke spared no labor or time to give the bureau the best that was in him.

The Ford Instrument Co. was greatly hampered at first by labor troubles and lack of space. But, with the bureau's assistance, Mr. Ford overcame these difficulties. By December, 1917, the company was speeding its work and better deliveries were being made. Mr. Ford, himself, was active and very able in the design of new and ingenious instruments, which have stood up well in service and have proven of great value to the Navy. Upon the entrance of the United States in the war, this company at the request of the Bureau of

ENEMY-BEARING SOLVER USED WITH FIRE CONTROL.

128-1

SPERRY BATTLE TRACER WHICH PLOTS A COMPLETE HISTORY OF MOVEMENTS OF OWN SHIP AND ENEMY SHIP, INCLUDING TIME BEARING, DISTANCE, AND COURSE.

TIME OF FLIGHT CLOCK WHICH RINGS A BELL WHEN THE SALVO IS ABOUT TO FALL, THEREBY ASSISTING THE SPOTTER TO IDENTIFY THE SPLASHES FROM THE GUNS HE IS OBSERVING.

DIRECTORSCOPE DOTTER, GENERAL ARRANGEMENT.

158–3

Ordnance gave over the entire time of Mr. Ford and his corps of assistants for the prosecution of Navy work, and supplied capital to greatly increase the equipment of the factory and build up an organization which was especially adapted for the development and manufacture of fire-control instruments. This necessitated the abandonment of important commercial projects then under way, including the manufacture of the Carrie gyro compass, and other work in which the company was engaged. The special value to the Navy of this organization lies in the personal ability and large experience in fire-control work of Mr. Ford, augmented by the able corps of engineers.

The company secured factory and office space amounting to 28,000 square feet, fully equipped with precision lathes, milling, drilling, and other machine tools especially adapted for manufacture of fire-control instruments, and employed about 300 employees on December 31, 1918. The company completed contracts for a total of about 2,000 instruments, containing over 2,000,000 separate parts, costing over $1,000,000.

The company produced the following instruments, which were accepted and ordered by the United States Navy Department:

1. Ford range keeper, Mk. I.
2. Ford range keeper, Mk. II.
3. Range-finder transmitter, Mk. II.
4. Range-finder indicator, Mk. II.
5. Flight indicator.
6. Time-of-flight clock, Mk. I, with alarm.
7. Range-finder coincidence trainer.
8. Directorscope transmitter, Mk. II, Mod. 3 and 4, Mk. IV, Mod. 0 and 1.
9. Multiple throw control switch.
10. Range converter, Mk. I, Mod. 0–1.

The demands for the "follow-the-pointer in train" system required extensive design and manufacture by the Sperry Gyroscope Co., of Brooklyn, N. Y. Their problem was a big one. Army contracts interfered, and it was difficult to determine what should take precedence. Fire control was advancing rapidly, and innumerable changes were necessary. The Sperry Co. cooperated earnestly with the bureau, however, and many difficulties were surmounted.

The Sperry Co. produced the system installed in all capital ships by which the guns follow a pointer in train, operated from a distant aloft observing station. This method of control is essential when the gun pointers have the enemy obscured from their view by smoke and by the spray of enemy shell.

The contract placed by the department with the Recording and Computing Machines Co., Dayton, Ohio, for the manufacture of broadside director firing receivers and repeaters provided for the

delivery of 282 training receivers, 282 elevating receivers, 68 training repeaters, and 68 elevating repeaters for battleships by April, 1918. This contract was placed in November, 1917. Although all possible assistance was given to the Recording and Computing Machines Co. in the manufacture of these instruments the first instruments were not delivered until May, and only a small percentage had been delivered to November 9, 1918. At this time the bureau, which owned the building, grounds, and machinery, canceled the contract, installed its own management, and proceeded to manufacture, obtaining greatly increased output under Lieut. George F. Jacobs, R. F.

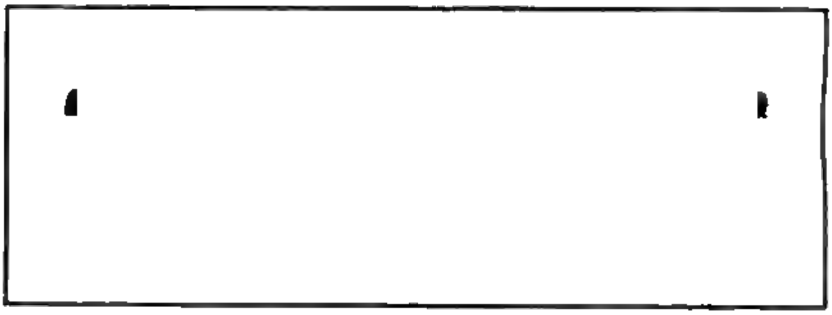
Range and deflection instruments for battleships and destroyers, manufactured by Charles Cory & Sons, were not delivered as expected. Destroyer instruments were particularly slow. The Cory Co. claimed this was unavoidable because of large contracts of the Bureau of Steam Engineering placed with them. The bureau accepted this explanation, although the attitude of the Cory Co. was one of passive submission. No effort apparently was made to increase production. The bureau offered such help as would aid deliveries, but the Cory Co. preferred not to accept these suggestions. Although dissatisfied with the Cory Co.'s attitude no action toward commandeering was taken.

Perhaps in no science has advancement been so swift as in the science of flying. War conditions stimulated research. During the first year of the war little attention was given to the control of fire against aircraft. During the second year this subject was broached but not until the third year was much progress made. The problem was very involved because of the speed of machines and their ability to maneuver in all planes. Reports from abroad indicated the desirability of employing sound, as well as sight, in aeroplane detection, and the development of an acoustic system was undertaken jointly by the War and Navy Departments. Assistance was rendered by the National Research Council and extensive experiments carried out by the Western Electric Co., and the first complete installation for protecting bases against bombing planes was erected at Pensacola, Fla.

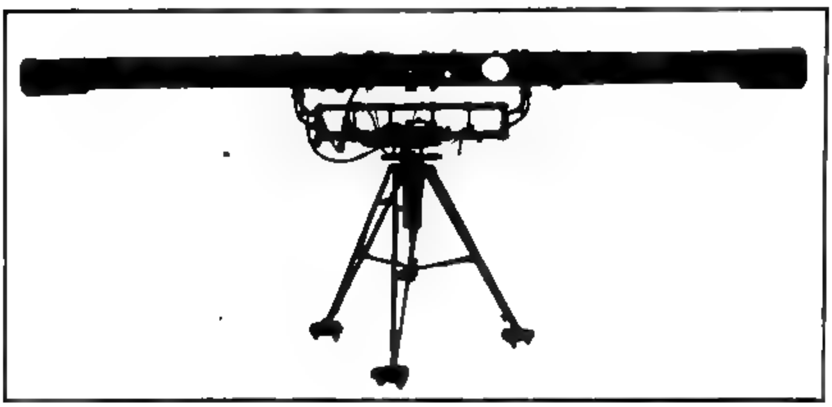
The antiaircraft station, at Pensacola, Fla., was set up by Lieut. H. C. Mittendorf, R. F., of the first control section. Great credit is due him, and to Lieut. F. T. Leilach and Lieut. H. E. Nichols of the U. S. Army Engineer Corps, for the successful operation of the system. To Dr. G. W. Stewart, of the State University of Iowa, is due the credit of developing the listening horns, which proved superior to all other types. This station has the only complete antiaircraft system in the United States.

The lessons learned as the war progressed and the demands for new apparatus to meet the new conditions of warfare have resulted in an

FORD RANGE KEEPER, MARK II, FOR USE WITH TORPEDO DEFENSE BATTERIES AND ON SMALL VESSELS.



INCLOSED RANGE-FINDER STAND FOR EXPOSED POSITIONS.



A 20-FOOT RANGE FINDER ON STAND.

160-3

END BOX REMOVED FROM RANGE FINDER, SHOWING MOUNTING OF END PRISMS.

All prisms, lenses, and mirrors must be in exact position, and all mechanical fitting must be within the smallest possible tolerance in order that the instrument function properly.

organization in the fire control section of the bureau about the time of the armistice as follows:

Chief of section	Comdr. W. R. Furlong, U. S. Navy.
Optics	Comdr. H. A. Orr, U. S. Navy.
Aid for optics	Mr. Lawrence Radford.
Fire control for battleships and cruisers	Lieut. Commander R. M. Comfort, U. S. Navy.
Fire control for destroyers and submarines	Lieut. Commander F. S. Craven, U. S. Navy.
Anti-aircraft fire control	Lieut. H. C. Mittendorf, R. F.
Range finders	Lieut. Commander A. A. Michelson, R. F.
Broadside directors	Lieut. (j. g.) J. J. Lamberty, R. F.

The foregoing account is, of necessity, only a brief *résumé* of the activities of the fire-control section of the bureau during the continuance of hostilities. It can truthfully be said that the magnitude of the fire-control problem in its various phases, mechanical, electrical, and optical, has increased enormously, both as regards design and production, and it is the earnest hope and expectation of the bureau that it may be able to keep fully abreast of all developments in this difficult field, and indeed serve as a pioneer in the solution of fire-control problems for the Navy.

CHAPTER XI.

TORPEDOES.

Toward the end of the last century, the development of the automobile torpedo introduced in the field of offensive weapons a very powerful rival of the gun. The torpedo was at first mounted on small craft known as torpedo boats (which in turn grew to the present-day destroyers), and later was supplied to battleships and cruisers. With the development of the submarine boat, the torpedo obviously became its prime weapon, and it is this instrument, as employed by the German submarine boats, which for a time seemed so near to winning the war for Germany, but which succeeded only in bringing into the conflict the United States and thus eventually terminating the struggle in the defeat of Germany.

The torpedo is essentially a missile, as much as the projectile fired from a gun. The projectile is fired at a high velocity by a heavy charge of explosive from a strong, very heavy gun. The projectile, once in air, continues its flight because of the initial velocity imparted to it in the bore of the gun. The torpedo is discharged from a torpedo tube by a light charge of powder or of compressed air, sufficient only to eject it from the tube. Thereafter, the torpedo propels itself through its medium, water (rather than the air of the projectile), regulating its depth and its steady forward course by delicate instruments contained within its fishlike body.

During the Spanish War, the torpedo had reached only a range of 800 yards with an explosive charge of 118 pounds. In the intervening years, the development of this weapon has been such that the torpedo of this last war held double the charge of explosive and was capable of more than a 10,000-yard range, 18,000 yards in extreme cases.

On the side of the enemy, the torpedo was the most important weapon of naval warfare in this war. On the side of the United States and the Allies, its performance has been disappointing, not because of lack of merit in the torpedo itself, but because of lack of opportunity for its use. The torpedo is primarily designed for use against surface vessels; it runs at a predetermined set depth and at-

tacks most dangerously the thin bottom of warships and of merchantmen. Its very accuracy of depth, however, militates against its efficiency against submarines, for, once the submarine is submerged, his depth is not definitely known and a torpedo fired against him is less efficient and less valuable—particularly since torpedoes will not explode except by actual contact—than a depth charge dropped from above him and exploding when it reaches the depth for which it is set, regardless of whether an actual hit is made.

In this war, however, when submarine dueled against submarine, then the torpedo was the only weapon of both combatants, and here it was that the torpedo found use on the allied side.

Although in the final analysis, but little active work was done by torpedoes in the war, this fact could, of course, not be known in advance; and the bureau was responsible at all times for the complete and proper equipment of our forces, battleships, cruisers, destroyers, and submarine boats, with their full quota of torpedoes, that they might be prepared to use them against enemy surface vessels if the enemy came out to do battle, and against submarines if a favorable opportunity offered.

From the original adoption of the torpedo to the present date, the bureau has endeavored to keep abreast and ahead of the times in torpedo design and supply, and there is maintained by the bureau an extensive system of torpedo manufacture, repair, overhaul, and issue.

On April 1, 1917, the status of torpedoes in the service was as follows:

Number assigned to vessels		1,040
Reserves:		
East coast	911	
West coast	95	
Philippines	40	
Canal Zone	10	
		1,056
Total number serviceable		2,096
Ordered and not delivered		2,806

The number of torpedoes given above, as in reserve, included torpedoes ready for issue to vessels about to be completed. Prior to and on April 1, 1917, the torpedo station was the center of distribution of torpedoes, all spare parts, replacement units, and all reserve torpedo stock. For each torpedo and torpedo outfit afloat, there was maintained, at Newport, a large stock of spare parts and replacement units. Much of the large manufacturing facilities of the torpedo station was employed in keeping the stock of spare parts and replacement units in sufficient quantity at all times to be ready to meet the demands for them afloat.

SINGLE TORPEDO TUBE, RIGHT SIDE, SHOWING TRAINER'S SEAT AND SIGHT.

ABOVE WATER, 21-INCH TRIPLE_TORPEDO TUBE, FOR USE ON DESTROYERS.

164-2

The Naval Gun Factory had only very recently taken up the manufacture of torpedoes, and consequently was never a main source of supply. In the spring of 1917, just prior to the declaration of war, the Naval Gun Factory was asked to speed up production on its existing orders for torpedoes, in order that the Navy might have sufficient torpedoes to carry out a policy which apparently would require a large expenditure of torpedoes afloat. This the gun factory did, but never at any time did this speeding-up of work in any way interfere with the set standard of production, which was maintained throughout the period of the war. The production was increased to approximately one torpedo a day, which meant a very large increase in the torpedo force and organization. The gun factory availed itself of every opportunity to promote all kinds of work relative to torpedoes, for the betterment of the service and in the interest of a more reliable weapon.

The Naval Torpedo Station at Newport, R. I., has long been the central torpedo station of the Navy, where overhaul, repair, and issue of torpedoes are carried on, and where the main supply of spare parts, reserve stock and replacement units is kept. Also, in connection with this station is the only official Government torpedo testing range, which is located in Narragansett Bay, about 4 miles north of the torpedo station. On this range all Government torpedoes are proved, all repaired torpedoes are reranged before issue, and all experimental work in connection with the development of new devices is carried on.

Just prior to and after the declaration of war, the torpedo station was engaged, in conjunction with the E. W. Bliss Co., in the design of a 21-inch torpedo for submarine boats. This problem had been acute for some time past, due to the performance of submarine boat torpedoes, in general, in the Navy, and due also to the peculiar conditions existing in the zone of naval operations, where it appeared that a very reliable and fast short-ranged torpedo could be used to very great advantage.

Another large feature of the torpedo station, Newport, has always been the carrying on of practically all experimental and development work in connection with torpedoes. This, unfortunately, was practically discontinued in the summer of 1917, and all plant facilities were immediately put into operation to expedite the manufacture of new torpedoes. While this policy at the time and under the circumstances was only proper, it has since proved to be undesirable, in that experimental work, which is so vitally necessary to the maintenance of a modern and reliable torpedo, was temporarily dropped in the interest of increased production.

The torpedo station was called upon to furnish the nucleus of the organization and personnel around which was built up the torpedo repair station abroad.

The torpedo station has also always been the training school, both for enlisted personnel and officers. Its facilities in this line were immediately taxed to the utmost upon the declaration of war. This was further aggravated by the fact that the destroyer program was put in advance of all other work, and it is these boats which require the maximum number of skilled personnel. There are two schools at Newport. First, the officers' school, with headquarters on torpedo testing barge *No. 2*. Here officers receive a thorough course in the handling, overhaul and maintenance of torpedoes afloat for war conditions. The course occupies approximately 12 weeks of intensive instruction, which includes the disassembling and assembling of torpedoes, their overhaul and actual firing, which is conducted from this barge in Narragansett Bay. The second school is for the enlisted personnel, for the training of torpedo gunners. This course is somewhat shorter than the officers' course and is confined more to overhaul, assembly, and firing adjustments. The headquarters of this school is ashore on the torpedo station, but two yard craft are fitted with torpedo tubes and other facilities, so that all men under instruction are given ample opportunity to actually run the torpedoes from these ships.

One of the greatest problems confronting the torpedo station in the summer of 1917 and subsequently was the maintenance of a large stock of spare parts, replacement units, and the carrying on of a greatly increased amount of overhaul. In addition to this, the assembly, with the necessary overhaul, of torpedoes, for the use of new boats was a problem of the first importance. However, by very careful planning and forethought on the part of the torpedo station, they were prepared and ready at all times to fill orders for spare parts and replacement units, and were able to maintain in a condition ready for issue a sufficient number of torpedoes to supply all new boats as they arrived.

During the period of the war, large increases in the plant and its facilities were made, these almost entirely in the interest of increasing production and increasing the facilities for the maintenance of an ever-growing stock of spare parts and replacement units.

The E. W. Bliss Co., whose plant is located at South Brooklyn, N. Y., has long been the Navy's main source of supply for the manufacture of torpedoes. They are, as the name implies, the nominal originators of the present standard type of United States Navy torpedoes, known as the Bliss-Leavitt.

On April 1, 1917, there were only 20 torpedoes approaching completion, although there was much material on hand and in various stages of manufacture.

The problem, just previous to and immediately following the outbreak of war, was the placing of contracts for very large quantities of material required for the building program. Large contracts were entered into with the E. W. Bliss Co. immediately after the outbreak of hostilities. Successfully to take up the work on these contracts, which were the largest that the United States Navy had ever let for torpedoes, it was necessary for the E. W. Bliss Co. to immediately take measures to increase its plant and facilities, in order that production might be expedited and delivery of torpedoes in quantity commenced as soon as possible. To this end the Navy Department entered into an agreement with the company, whereby they were to expand their manufacturing facilities by factory extensions which would increase their floor space by approximately 40 per cent. This was to take the form of a new building, and all floor space coming under this agreement was to be devoted in its entirety to the manufacture of torpedoes under pending Navy contracts during the war. The cost of these extensions—about $2,000,000—was advanced by the Government, to be repaid by the company, including interest at the rate of 4 per cent, by proportionate deductions from each final payment on torpedoes when delivered.

The understanding was that, with these plant extensions, the Bliss Co. would increase its output to at least 300 torpedoes per month, commencing in the month of July, 1918. This they never succeeded in doing, the largest month's delivery being in December, 1918, when 150 torpedoes were delivered. The failure of the Bliss Co. to meet its obligations and promised deliveries was, however, largely due to difficulties in obtaining air flask forgings from steel manufacturers.

There is maintained, at the works of the E. W. Bliss Co., a large force of Government inspectors. This organization, at all times, exerted its influence in the interest of increased production and the delivery of a more reliable weapon to the Government.

In the summer of 1918, it became apparent that the Bliss Co. would never be able to meet its promised deliveries of 300 torpedoes per month. The bureau was then confronted with the very serious problem of providing torpedoes for the rapidly increasing number of new ships, and to replace the predicted expenditure of torpedoes in the zone of naval operations. The deliveries of the Bliss Co. reached 153 a month.

These low deliveries brought to the attention of the bureau two or three very important facts in considering plans concerning some

future time, when it might be necessary to rapidly increase production of torpedoes. Too much emphasis can not be placed on the necessity of having available plants capable of producing air flask forgings. To produce an acceptable forging is a very difficult task, and requires considerable actual experience on the part of any company, experience which can only be gained through actual manufacture. Another is the problem of having available numerous sources of supply for the various parts which make up a torpedo. This work also requires very considerable experience, and can not be successfully undertaken at once, but must be developed in peace times through actual manufacture of these parts.

It has long been one of the cherished ambitions of officers who have been vitally interested in the torpedo program of the Navy to see a torpedo assembly plant erected. The idea of a torpedo assembly plant has as its foundation the complexity of the present torpedo. It has been amply demonstrated on numerous occasions that the manufacture of parts for torpedoes is an art and can not be taken up and satisfactorily done without training, which necessarily should be done in peace times. Therefore, if an ideal is to be met, whereby a peace organization can suddenly be shifted to a war organization, with its subsequent increase in demand for the number of torpedoes produced, it has long appeared that the only practical way to accomplish this was by "farming out" the various parts and units of torpedoes to reliable manufacturers in peace times, so that they could become acquainted with the standard of work necessary satisfactorily to produce these parts, and so that, in the event of an emergency, all these various plants where different parts are made could be immediately speeded up and, in turn, a huge assembly plant could be rapidly transformed from a peace-time basis to a war footing, where torpedo output could be very quickly increased.

In the summer of 1918, the torpedo situation, because of low deliveries, became acute, and the bureau was confronted with the problem of finding a new source of supply for torpedoes, which were presently going to be needed. It was then that the opportunity presented itself to bring into existence such a great assembly plant, with all the advantages which make such a plant a valuable asset to the Navy.

The situation was presented to the Secretary of the Navy in August, 1918, and he approved the project. There followed, immediately after this, a search for a suitable location for this plant, and a site at Alexandria, Va., on the Potomac River, was finally agreed upon. Steps were immediately taken to acquire the property and to prepare the plans for this plant. Alexandria affords a very favorable location for such a plant, as it is very near the fleet base at the

21-INCH TORPEDO TUBE, SUBMERGED TYPE, FOR USE ON BATTLESHIPS.

BOW NEST OF TORPEDO TUBES FOR SUBMARINE, MOUNTED FOR TEST.

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mouth of the Potomac River, and also will have a standard proving range in Chesapeake Bay for torpedoes assembled there. This range is to be equipped with all the latest devices for recording the performance of torpedoes in the water and is to be the longest range that the Navy has—20,000 yards.

Capt. W. S. Miller, U. S. Navy, was placed in charge of the Alexandria torpedo station project, and the plant, conceived as a war measure, but of undoubted value in peace times, has been constructed since the armistice.

Shortly after the first destroyers arrived in the zone of naval operations it became apparent that there would have to be some sort of torpedo repair and overhaul station ashore at the destroyer base. On November 16, 1917, the Secretary of the Navy ordered the establishment of a torpedo repair station at Queenstown, Ireland. A small force of 2 officers and 23 men, under the command of Lieut. Commander Radford Moses, proceeded to assemble the necessary power plant, testing material, tools, and spare parts and sailed from the United States on December 17, 1917, taking material with them for the establishment of a station capable of caring for 130 torpedoes. A number of these men were civilian torpedo machinists at the torpedo station, Newport, R. I., who volunteered and were enlisted for this particular duty.

On December 30, 1917, work was started in the British dockyard at Haulbowline, Queenstown, Ireland, taking over part of the British torpedo shop. This station proceeded with the overhaul of torpedoes for the destroyers so that it was only necessary for these vessels to make the firing adjustments to their torpedoes. The destroyers were thus relieved of work which would have been very difficult to perform due to the large percentage of time underway, bad weather conditions, and lack of technical knowledge on the part of destroyer torpedo personnel caused by drawing heavily on them for nucleus crews.

On April 1, 1918, a building known as the paravane shed at Haulbowline was turned over by the British for this repair station, and, on May 1, this building (65 by 100 feet) was put in operation, and, by means of the Diesel engine, power plant, and air compressors brought from Newport, R. I., was made entirely self-sustaining.

On July 1, 1918, the force commander decided that this station should be expanded to provide for the overhaul of all torpedoes north of the Mediterranean. The British Admiralty agreed to extend the building to a total length of 325 feet, and it was decided that the United States Government would bear one-half the expense of this permanent construction. The quarters previously erected by the torpedo men were expanded by the addition of portable buildings to provide for quartering 150 men and 17 officers (for instruction). The remaining men necessary to carry out the force com-

mander's plans—namely, overhauling 400 torpedoes per month—were to be quartered at White Point Barracks.

All temporary buildings were erected completely by the torpedo repair station force, assisted by eight men from the U. S. S. *Melville*. The permanent shop extension was only about one-half completed when the armistice was signed.

A class of instruction for officers and men was started and a total of 58 officers and 34 men were instructed in torpedoes. Vessels having torpedoes at the torpedo repair station were required to send one man to witness all tests, and were allowed to send two men for torpedo instruction.

The number of torpedoes overhauled per week was increased as new men were instructed in the work and during the final week before the armistice was signed 45 torpedoes were overhauled. A total of 520 torpedoes were completely overhauled by this station, of which number 82 were received from vessels based on Brest, 11 from vessels based on Plymouth, and 15 from the submarines at Berehaven, and in addition to these 309 were partially overhauled. When the armistice was signed the complement of this station was 13 officers and 185 men.

During the progress of this work, many unforeseen conditions were encountered, and the chief special mechanics enlisted for torpedo duty were required to perform structural work and labor of all kinds in addition to their daily torpedo employment. Great credit is due these men, who were civilians but a few months before, for their untiring energy in the establishment of this station and for their excellent behavior and cooperation with the dockyard enlisted men and civilian employees. To the few men of the regular Navy, including the chief gunner's mates, is due the credit for supervising and producing work which was satisfactory to the destroyer flotilla. In the progress of building and demobilizing this station, the only civilian labor employed was on permanent construction.

During the latter part of the summer and the early fall of 1918, there was established at Brest another base, and it was further contemplated to establish other destroyer bases in the Mediterranean. However, Queenstown is to all intents and purposes the only station which had the facilities and the personnel to perform the necessary overhaul work.

Immediately after the signing of the armistice, steps were taken to abandon this station, and it was picked up bodily and put aboard ship and returned to the United States. The special enlisted personnel were also returned to their former duties at the naval torpedo station, Newport.

The largest contracts let by this section of the bureau, aside from torpedoes, were contracts for torpedo launching tubes and torpedo

TORPEDO REPAIR STATION

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TORPEDO REPAIR STATION, POWER PLANT, QUEENSTOWN, IRELAND.

air compressors. The Crucible Steel Co. of America obtained two contracts for triple, Mk. III, above-water, torpedo launching tubes; the first contract on June 12, 1917, for 100 tubes, and the second contract on October 18, 1917, for 200 more. These large orders for tubes, in connection with other large orders to the Naval Gun Factory and the Navy Yard, Puget Sound, were necessary to meet the destroyer building program.

The Crucible Steel Co., for various reasons, failed to meet the contract rate of delivery, although, after the signing of the armistice, their deliveries were uniform and satisfactory.

In addition to the Crucible Steel Co., the Navy Yard, Puget Sound, Wash., took up the manufacture of torpedo tubes. This yard was awarded orders totaling 554, 21-inch, Mk. III, tubes as follows:

June 26, 1917, triple tubes	26
July 19, 1917, triple tubes	44
Nov. 20, 1917, triple tubes	160
Feb. 8, 1918, triple tubes	160
May 10, 1918, triple tubes	164

When it became apparent that deliveries from other sources would not be adequate, the bureau immediately took up, with the Puget Sound Navy Yard and the Washington Navy Yard, the proposition of increasing their promised tube deliveries to the very utmost. This both yards did, and the Puget Sound yard reached the remarkable production of 45 of these tubes per month. Had it not been for this tremendous increase in production, destroyers would have been commissioned without a part, at least, of their tubes.

Orders were also given to the Naval Gun Factory totaling 252 torpedo tubes, 40 of these for submarines Nos. 109 to 118.

These orders, at the request of the bureau, were expedited, and the Naval Gun Factory more than doubled its production of tubes.

The largest contract for torpedo air compressors was let to the Worthington Pump & Machinery Corp. on November 22, 1917, 300 of these machines being ordered on that date. There was considerable trouble over the award of this contract, as the contractors had had no experience in building torpedo air compressors for the Navy, and because, as the bureau was planning on a very rapid delivery of compressors, no time could be lost or wasted in experimenting to produce a satisfactory compressor. However, contract was finally awarded them, and after some slight initial delays, due to obtaining material and priority, this company commenced to turn out these air compressors very rapidly, and reached the production of 45 machines a month, which met every possible requirement of the building program. The contractors are worthy of very special commendation for the zeal which they manifested in this work and the promptness of delivery which was shown.

already in process of manufacture. Two of these torpedoes will have range in excess of any torpedoes now known to exist, while the third will be capable of a range at a speed greater than any yet realized.

Despite the pressure of work upon production during the war, the bureau considers that greater advances and improvements in torpedoes have been accomplished during this time than for a long period of years.

The personnel of the torpedo section of the bureau had for some years prior to January 1, 1917, consisted of one officer and one clerk. The clerk, Mr. E. L. Bennett, had remained in the service of this section continuously, while officers had come and gone to this station as shore duty. On January 1, 1917, the section was in charge of Commander J. V. Ogan. The demands on this section steadily and rapidly increased, commencing just prior to the declaration of war and continuing throughout the war. In March, 1918, Commander Ogan was relieved to go to sea, and his place was taken by Commander George B. Wright.

The interests of this section cover a very wide and divergent field, both ashore and afloat, and the increasing importance of the torpedo as a reliable weapon is demanding more and more personnel to carry on the work necessary to the maintenance of this material, both ashore and afloat; to formulate the policy regarding the handling, use, issue, and overhaul of this material; and, finally, to carry on the vast amount of development and experimental work that is absolutely necessary to keep the ships equipped with the latest and most reliable type of torpedo.

One of the most serious difficulties encountered during the expansion of this section into a war basis was the lack of highly trained personnel, both ashore and afloat. The complexity of the torpedo, its care, its tests, and its running are of such a nature that they can only be successfully accomplished by men who have had long practical experience with torpedoes. This lack of men was seriously aggravated by the continual assignment of the few on shore to sea duty without relief.

CHAPTER XII.

TURRETS.

Everyone is familiar with the exterior of the heavy gun turrets of our battleships. They form probably the most conspicuous part of the ship itself when viewed from any angle, and rightly, for these turret guns are the fighting part of the ship.

Only those who have been inside a battleship turret can appreciate the enormous mass of machinery that is assembled within the barbette, or armored tube, which surrounds the turret. Ton after ton of machinery is crowded within the confines of this small space to operate the guns in action. The guns themselves are so mounted in the turret that only a movement in elevation is permitted; that is, the muzzles of the guns can be raised or lowered, but can not be moved right or left independently. Movement in train is accomplished by moving the entire turret around until it points in the proper direction.

Our present turret design is the result of years of growth and development, by which we have learned the many little things that made improvements necessary. From long experience we have drawn the principles of design and construction which underlie the construction of the turrets for 14-inch and 16-inch guns on our latest ships.

It is quite natural, therefore that turret design and construction did not undergo any revolutionary change during the war. There was, however, a constant, gradual change and improvement, for, by observing the details of the construction and operation of turrets of ships of foreign navies, a thing we had never before been able to do, we learned many practical points and kinks of operation that resulted in much gain.

The fundamental principles of turret design in all navies are very much the same. Foreign navies, like ourselves, have gradually developed the principles of mounting guns in turrets, and, as these improvements have kept pace with progress in the art of shipbuilding, there is little to choose along the broad general lines of design among the turrets of ships of the various countries.

Turret construction and the mounting of big guns aboard ship is a constant struggle between the guns and their turrets and the means of installing them on board ship. The gunmaker can build an 18, 20, or even 24 inch gun, but it is useless to construct such a gun unless the shipbuilder can build a vessel large enough and strong enough to permit mounting it and stand the shock of fire.

Since our earliest battleships, the Navy Department has placed the ship's heaviest guns in turrets. Thus, in the course of the Navy's development, there are the old low-powered 13-inch guns on the *Indiana* and *Massachusetts*, mounted in pairs in turrets. Then came the 12-inch 35-caliber guns of the *Iowa*. The 8-inch guns were placed in turrets of their own, two guns to a turret. Next, in the effort to utilize the same barbette, the 8-inch turret was superimposed on the 12-inch and there resulted the double-deck turrets of the *Georgia* class, with two 12-inch guns in the lower turret and two 8-inch guns in the upper. The *Connecticut* type, the last of the predreadnaughts, reverted to the single-deck turret and carried a battery of four 12-inch guns in two turrets and eight 8-inch guns in four turrets.

With the dreadnaughts the turret design was carried on, except that the 8-inch turrets disappeared and a number of 12-inch turrets were installed, until the *Wyoming* and *Arkansas*, each with twelve 12-inch guns in six turrets, two guns to a turret. With the development of the larger guns, the *New York* and *Texas* mounted 14-inch guns two to a turret. To save weight, a 3-gun turret was developed; and our latest battleships, the *Idaho* type, carry twelve 14-inch guns in four turrets, three guns to a turret, while ships now contemplated will carry twelve 16-inch guns.

Few appreciate the weights of material dealt with in turret mountings for our heavy guns. For instance, the 14-inch 50-caliber gun weighs 95 tons. The slide in which it is held weighs in the neighborhood of 25 tons, and the steel castings, which are bolted to the structure of the turret to support the gun and slide, weigh about 10 tons. Three complete guns, with complete operating equipment consisting of powder hoists, rammers, shell hoists, etc., form a single turret in our latest ships, so that the weight of each of the four 14-inch gun turrets, each carrying three guns, is not far from 2,500 tons; of which total, of course, the armor is the greater part.

Some conception of the enormous size of these turrets is necessary to understand the problem facing the Bureau of Ordnance in seeing that this equipment is at all times in perfect condition, ready for operation on instant notice. Successfully to operate a turret, every piece of machinery, *without exception*, must be in perfect adjustment and condition. All parts of the turret are so interlaced, and the machinery is so complicated, that the failure of one part means a serious reduction in the efficiency of operation of a turret,

BREECH MECHANISM OF 14-INCH GUN. OPEN POSITION.

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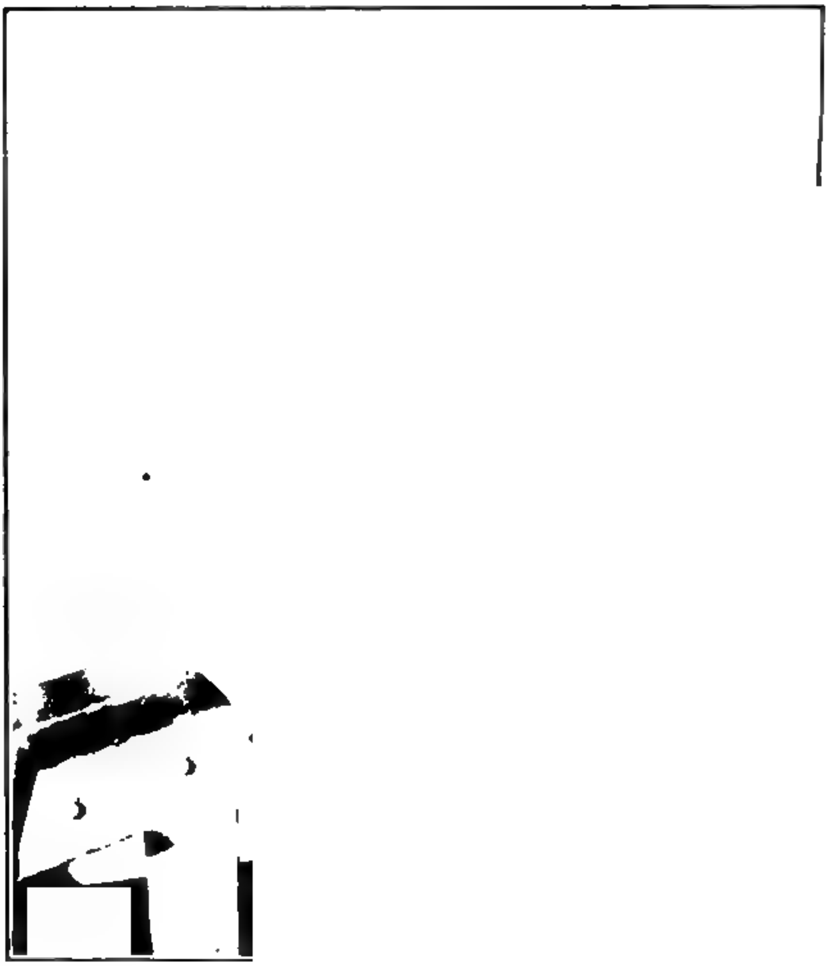

14-INCH PROJECTILE AT TOP OF SHELL HOIST READY TO SWING OUT ON LOADING PLATFORM.

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14-INCH PROJECTILE IN CRADLE BEING SWUNG TO LOADING PLATFORM.

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BOTTOM OF 14-INCH SHELL HOIST, SHOWING PROJECTILE, TUBE-HOIST CONTROL MECHANISM, CAPSTANS FOR PARBUCKLING, AND MOTOR CONTROL.

BATTERY OF RAMMERS FOR A 3-GUN TURRET READY FOR SHOP TEST.

14- INCH RAMMER, SHOWING CHAIN HOUSED IN CASING

RAMMER EQUIPMENT FOR 14-INCH TURRET VIEWED FROM THE REAR, SHOWING BACK GEARING AND THE FOLDING SPANNING TRAY IN FRONT OF THE RAMMER.

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14-INCH SLIDE ON PLANING MACHINE.

TURRET SIGHT YOKE WITH TELESCOPES AND RANGE AND DEFLECTION DRUMS.

ELEVATING GEARS FOR 14-INCH 3-GUN TURRET, SHOWING CROSS CONNECTING SHAFT AND MOTOR-CONTROL SHAFT.

if not actually disabling it and placing it out of action. One weak or cracked part, in one of the many machines crowded into the armor-plate walls of the turret, or one loose connection, which results in the failure of a motor to function properly, may cause a 25 per cent diminution of the gun power of the ship, by placing one turret out of action.

Throughout the war, the Bureau of Ordnance maintained all of the turret equipment of our battleships in as nearly perfect condition as it was humanly possible to do. Foreseeing the possibility of hostilities, every step had, at the outbreak of war, been taken to place the turret equipment of our battleships in condition ready for action. Reserves of spare parts had been accumulated and issued to the ships, so that breakages, that will invariably occur, could be easily replaced. Special mechanics from the Naval Gun Factory were sent to the fleet to overhaul and adjust all sights, to insure that they were all in the best possible condition.

During the war, two new ships, the *Mississippi* and *New Mexico*, were commissioned. These ships mount twelve 14-inch 50-caliber guns, and are equal in gun power to any ship in the world.

One of the new developments of the past two years, hastened and, in fact, forced by the outbreak of the war in 1917 was the decision to change the armament of battle cruisers from 14-inch to 16-inch guns. As originally laid down, the battle cruisers were to carry the armament of eight 14-inch 50-caliber guns. As the plans now stand, the battle cruisers will carry armament of eight 16-inch 50-caliber guns. This change will give the United States battle cruisers the heaviest armament of any ships of their class in the world.

The 14-inch 50-caliber gun is 50 by 14 inches—700 inches, or 58⅓ feet long. In describing a gun, the diameter of the bore and its length in calibers are always given; that is, the number of times the diameter of the bore is contained in its length. The 16-inch 50-caliber gun is 800 inches or 66⅔ feet long, an increase in length of about 15 per cent. This increase in length, combined with the increase in diameter of the bore, results in an increase in muzzle energy of 50 per cent. The 14-inch gun throws a projectile weighing 1,400 pounds, while the 16-inch gun throws a projectile weighing 2,100 pounds, and, as the muzzle velocity imparted to the projectiles by both guns is 2,800 feet per second, the 16-inch gun is nearly 50 per cent more powerful than the 14-inch gun.

The Navy Department's decision to change the guns of the battle cruisers from 14 to 16 inch, made upon the initiative and after the repeated recommendations of this bureau, was, in effect, a decision to give the battle cruisers a 50 per cent heavier armament. In action, these battle cruisers will throw a weight of metal of 16,800 pounds,

or about $8\frac{1}{2}$ short tons per broadside. With their speed of 33 knots, these ships should by far surpass all other similar ships of foreign navies.

Taking lessons from the casualties on board the British and German ships in the battle of Jutland, steps were taken for the better flame-proofing of turrets to prevent casualties, should flarebacks, etc., occur in action.

The entire counter recoil systems of the turrets of our ships, the *Texas*, *Oklahoma*, and *Nevada*, were overhauled, several of our ships received new powder hoists, and several received shell hoists. All alterations and repairs were accomplished without interfering with the ship's most important mission—that of being ready for battle at all times.

Every ship while at sea had its turrets ready for instant use, and every favorable opportunity was taken to overhaul and examine the auxiliary operating equipment and keep it in perfect condition as far as possible.

The officers who handled this work were Commander W. R. Van Auken, June 8, 1916, to April 20, 1917, and Lieut. Commander L. B. Bye, April 21, 1917, to June 7, 1919. This section of the bureau also had cognizance over the railway and tractor batteries, and information, which are described in other chapters.

The real test of the efficiency of the measures taken by the Bureau of Ordnance to keep our battleship turrets in operating condition was encountered when our battleships took their place in the line of battle of the British Grand Fleet. In order to operate there, it was absolutely necessary that every piece of equipment, and particularly the ordnance equipment of the ships, be ready for battle at any moment, for no one knew when or where the German Fleet would essay to sally forth. The fact that the ships did operate successfully is the best assurance of satisfactory work.

CHAPTER XIII.

THE UNITED STATES NAVAL RAILWAY BATTERIES.

For two months previous to the signing of the armistice, the United States Navy had in action in France, firing against German troop centers, railroad centers, and points of vantage all along the line, the five heaviest mobile guns on all the western front. The Navy, thus in accordance with methods in previous wars, assisted the Army by operating some of its guns on shore, a duty for which its personnel is by sea training peculiarly fitted. The French and Germans did likewise in the early days of the war, and as time went on and the far-reaching effect of naval bombardment from long-range guns began to be more and more manifest, continually increasing numbers of naval guns were put to this use.

The Germans, for the most part, adopted the plan of mounting their naval guns on fixed shore emplacements, probably because they had a greater number to mount, and they looked for an early victorious close of the war, so that they felt it advisable to get them in action quickly without taking the time necessary to build large railway mounts. They had for some time previous to our entrance into the war dismantled many of their battleships and had placed the guns in action at the front, some on railway mountings, manned by naval personnel. The Allies, as well, had, before the entrance of the United States into the war, begun to reply to the Germans by adopting their own tactics and improving upon them. With infinite care the French built all along their front-line railways numbers of curved sidings, so that on almost instant notice and from almost any point along the front line a bombardment of the Germans could be commenced by railway artillery.

Both the French and British lent their efforts, as far as they could, to the construction of railway artillery and the placing of railway guns in service in France. As was the case with the Germans and the Italians, these guns were in practically all cases manned by naval personnel.[1]

When the United States entered the war against Germany in 1917, the Germans had the better of the long-range artillery argument. Their railway guns outranged those of the British and French.

[1] Extract from Landing Guns on the Belgian Coast, Chap. VII, Vol. I, "The Dover Patrol, 1915–1917," by Admiral Sir Reginald Bacon, K. C. B., K. C. V. O.

"In all big wars it has been the privilege of the Navy to land larger guns than those generally used ashore; so, in this particular, the Dover Patrol was able once again to uphold an old tradition of the Navy."

The Chief of Bureau, convinced of the importance of long-range guns on the western front, on November 12, 1917, recommended to the Chief of Naval Operations the strategic advantages to be gained by placing several of our 14-inch naval guns in action in France.

In making this recommendation, the Chief of Bureau was guided by a close study of the situation abroad which had convinced him that naval guns were needed on shore, to do their part in reducing enemy concentration points, ammunition dumps, and railway lines.

A number of 14-inch 50-caliber guns were available at that time for such uses. These guns were reserve guns for the ships of the Navy in commission and under construction. The probability of their need at sea was slight. On the other hand, their value ashore could be great. The guns were nearly 60 feet long, weighed 90 tons apiece, and fired a projectile containing 88 pounds of high explosive, with a total weight of 1,400 pounds, at a muzzle velocity of 2,800 feet per second, reaching a maximum range, at 43 degrees of elevation, of over 25 miles.

The proposal to place a number of guns on railway mountings, for use with the American Army in France, was approved by the Chief of Naval Operations on November 26, 1917, and, after considering preliminary designs and the best method of using the guns, on December 26, the day after Christmas, the naval gun factory was instructed by the Bureau of Ordnance to work out the details of a plan for mounting the 14-inch 50-caliber naval rifles on railway cars. Work was continued night and day at the Naval Gun Factory, so that on January 25, 1918, complete plans and specifications for the material of the expedition were ready for submission to the bidders.

The battleship turret mount designers, together with men with experience in bridge and locomotive work, called into action to develop the plans, succeeded in less than 30 days in turning out the complete plans for the equipment.

The work of design was done at the Naval Gun Factory by the force under Commander Harvey Delano, whose right-hand man in all this work was Mr. George A. Chadwick. The work of this designer was remarkable and it is primarily due to his excellent judgment that the batteries as assembled carried out their mission thoroughly on the firing lines in France. Capt. A. L. Willard, in charge of the factory, kept up the enthusiasm of the personnel at this task and by his experience and able suggestions guided the project successfully and efficiently.

To Lieut. Commander L. B. Bye, United States Navy, fell the task of coordinating all the efforts to accomplish the manufacture and shipment of all the guns, mounts, carriages, cars, locomotives, and a multitude of other necessary equipment.

14-INCH GUN ON RAILROAD GUN CAR. TYPE USED ON WESTERN FRONT BY U. S. NAVY.

INSIDE OF AMMUNITION CAR, 14-INCH RAILWAY BATTERY.

PLACING 14-INCH 50-CALIBER GUN ON GIRDER FOR TRANSPORTATION TO THE SHOPS

REAR ADMIRAL C. P. PLUNKETT, U. S. NAVY, AND THE OFFICERS OF THE U. S. NAVAL RAILWAY BATTERIES, WEARING FIELD UNIFORMS SIMILAR TO THAT OF THE ARMY.

The bureau consulted Army authorities, and Maj. Gen. John Headlam, of the British Artillery, who won fame at Mons, also was of great assistance in outlining the project and in drawing up the general requirements which a heavy railway mount must fulfill.

In general, the designs called for an initial construction of five battery units, each battery unit composed as follows:

1 gun car, consisting of two large main girders, each 72 feet long, braced and tied together to form a single girder unit with a large center well in which the 14-inch 50-caliber gun with its slide, deck lugs, elevating gear, etc., was mounted. The gun was arranged to fire from the rails at angles of elevation up to 15°. For firing at elevations from 15° to 43° a foundation composed principally of ordinary structural-steel girders and timbers was provided.
1 locomotive.
2 ammunition cars.
1 construction (gondola) car, 1 construction (flat) car with crane, and 1 sand and log (box) car, for carrying foundation material and installing it.
1 workshop car.
1 fuel car.
3 berthing cars and 1 kitchen car for housing operating personnel.
1 battery headquarters car for operating offices, housing officers, etc.

In addition, provision was made for a staff train of:

1 locomotive.
1 staff quarters car.
1 traveling machine shop.
1 spare parts car.
1 staff quarters car.
1 staff kitchen and dispensary car.
1 staff commissary car.
1 staff berthing car.

In all, the initial plans for five units called for:

5 gun cars.
6 locomotive cars.
10 ammunition cars.
5 crane cars.
11 construction cars.
10 fuel and workshop cars.
16 berthing cars.
6 kitchen cars.
1 traveling machine shop.
13 headquarters, commissary, dispensary, etc., cars.

THE DESIGN OF THE GUN CAR.

The heavy weights to be handled and the limitations of French tunnel clearances, track and bridge weights, made design a difficult problem and called for close and careful calculations.

The total weight of the gun car complete is in the neighborhood of 535,000[1] distributed as follows:

	Pounds.
Gun, breech mechanism and yoke	192,500
Slide, complete	50,200
Elevating gear (screw)	650
Elevating gear (nut)	2,930
Elevating gear details	1,860
Deck lugs (2)	10,200
Transom casting	10,000
Cab	12,400
Shell-loading device	1,290
Girders, including braces (2)	135,830
Trucks (4)	80,000
Truck beams (2)	33,000
Compressor, winch, and engine	1,800

[1] A New York Central locomotive and its tender, class 1,800, weighs 518,240 pounds.

The gun was to be capable of firing at angles of elevation from 0° to approximately 43°. The ensuing reactions due to firing are: At 0°, gun horizontal, trunnion pressure and resulting horizontal reaction, 814,000 pounds. At 43°, trunnion pressure, 966,000 pounds; resulting horizontal and vertical reactions, approximately 700,000 pounds each.

Each of the two longitudinal main girders is 72 feet long, with a maximum depth of approximately 8 feet. The firing load is concentrated, and to properly care for it and insure its distribution through the girder section, the web of the girder, where the deck lugs are applied, is made especially heavy. Special plates were necessary for this section. The two main girders are tied together, and cross-bracketed at each end to form a single girder unit, which weighs 135,830 pounds. A special U-shaped housing is built in at either end of the girder, in which cast-steel H beams, each carrying a center-pin socket, are placed. The center-pin socket of the H beams, respectively, receive the center pins on the two 12-wheel car trucks placed at each end of the girder on which it rests.

The construction of the trucks to carry the gun car is, of course, extremely and exceptionally heavy. Structural steel-girder beams form the frames of the trucks and carry the load to the axles. The axles of the trucks turn in 9-inch by 12-inch boxes, arranged with coil and equalizing springs to insure an even distribution of the load.

The gun is placed in the well, formed between the two girders. To accomplish this, the deck lugs are fastened directly to the web at its heaviest section by means of steel bolts, ground to size to insure a correct fit and an even transmission of the firing stresses. The slide, with the gun and its yoke, is then installed between the lugs, the elevating gear, which consists of a worm in an oscillating bearing operated by hand through a train of gears, being placed beneath and fastened to the girder flanges and crosspieces.

Sufficient clear space is left behind the face of the breech of the gun, so that when the gun fires at angles of elevation not greater than 15° (at 15° elevation the range of the gun is 23,000 yards), all that is necessary is to set the hand brakes on the gun car, after the gun has been properly aimed, and fire. The recoil of the gun is absorbed by the hydraulic brake, and the resultant reaction on the gun car is taken up in moving the entire car backward along the tracks. At 15° the gun car moves backward a distance of about 25 feet. The trunnions of the gun are placed

so that the load on the axles of front and rear trucks is equalized on firing.[1]

THE GUN CAR PIT FOUNDATION.

To enable the gun to fire at angles of elevation greater than 15°, arrangements for a pit and foundation, as mentioned above, have

[1] On Mar. 23, 1918, two days after the German Army opened its great offensive. the whole world was stirred by a long-range bombardment of Paris. An explosion from a mysterious source occurred on the Quai de Seine at 7.15 a. m. that day, this being followed by similar ones at about 15-minute intervals, until by evening 21 such explosions had occurred. An investigation by the allied air forces developed that this bombardment was being carried on by a gun of novel construction and design located within the German lines in the forest of Gobain of Laon, and operating at a distance of 68.8 miles from Paris.

Many interesting theories were advanced to account for this unexpected achievement. A great deal was published, and there was a great deal of speculation concerning the German gun and mount. It was generally supposed at the time that the gun was mounted on a concrete emplacement, from which it was carefully positioned in elevation and direction to fire on Paris.

Now that the facts concerning the German guns are available, it is possible to make the following comparison of this German gun and those used on the Navy railway mounts:

	Maximum range.	Weight of projectile.	Muzzle velocity.	Maximum firing angle	Muzzle energy.	Brake load due to firing.
	Yards.	*Pounds.*	*Foot-sec.*	°	*Foot-tons.*	*Pounds.*
German gun	121,000	204	4,760	55	41,500	127,500
United States naval gun	45,000	1,400	2,800	43	76,087	800,000

From the above data it will be seen that although the range of the German gun was greater, it fired an extremely light shell compared to that of the American gun, and that in all other respects the comparison is favorable to the American gun. The muzzle energy of the American gun and the forces acting on the trunnions greatly exceeded that of the German gun, and on this account the designing of the American mount was much more difficult. It is now known that the German guns were transported from place to place over existing railways by a specially designed car, and were fired from turntable emplacements which made possible a considerable movement of the guns in train.

It is interesting to note that the girders employed by the Germans for carrying the weight and recoil shock of their long-range gun involve strength lines similar to those worked out independently by the Bureau of Ordnance in its girders for the 14-inch Mark I gun car.

There are other points of similarity in the mounts. The main girders were similar in construction and appearance, and the truck arrangements in the case of the Mark II mount and the German mount are identical. Their design details differ markedly from those of our Army and of the French. In addition to the above, the American mount was exceedingly more mobile and flexible, was designed to fire from the ordinary railroad track within 10 minutes after arrival at the site, an extremely valuable feature in the case of a rapid movement of troops. It should be stated, however, that there is no record that the Germans contemplated firing from the tracks, as was the case in the 14-inch naval mounts, and their design did not include the features necessary for such firing.

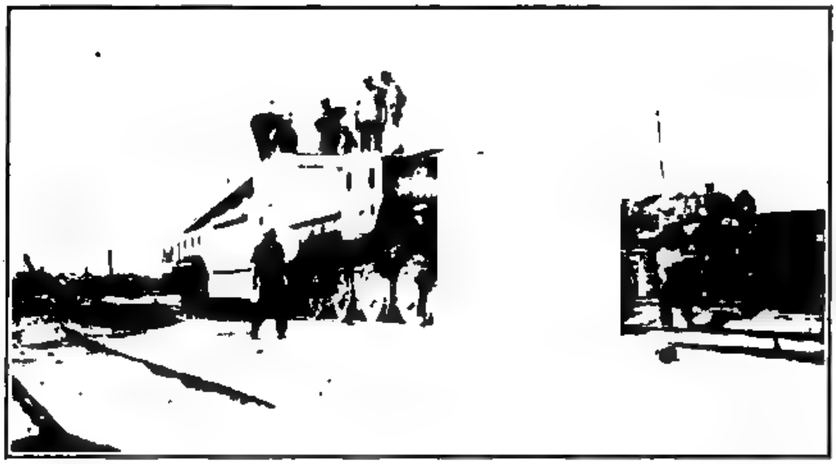
In the case of the turntable used by the Germans in the Forest of Gobain, it required two weeks to erect in the field after the site had been selected. Much preliminary preparation was necessary before the erection of their turntable could be proceeded with. A shop crane was necessary for the handling of the heavy weights of the turntable, this crane requiring the use of considerable extra equipment for its installation. In the case of a turntable that was later proposed by the Bureau of Ordnance for the 14-inch Mark I railway mount, should these mounts be desired for mobile coast defense, the time estimated to erect the turntables in position in the field to fire was 24 hours after the selection of site and arrival of the turntable equipment. Weights were limited to 5 tons, so that they could be readily handled by means of a pillar crane which was part of the train equipment.

been provided. Immediately below the elevating gear, and securely fastened to the girder webs and flanges, is a heavy steel casting called the transom bedplate casting. A similar casting is provided in the foundation. The entire foundation is prepared in advance, it usually taking about 20 hours to get it ready. It is, of course, prepared in advance of the arrival of the gun car at any point at which the gun is to operate. The pit is dug, and by means of the crane car provided, the timber work backing and the structural steel girders are put in place. The foundation bedplate casting is then put into position, and the girders, designed to carry the rails and the weight of the gun car when it is rolled into position over the foundation, are placed.

To prepare the gun for firing from the pit foundation is then a matter of but a few minutes. The car is run over the foundation, until the transom-bedplate casting of the gun car is directly over the bedplate casting of the foundation. One-hundred-ton ball-bearing jacks are then placed under the corners of the H beams at each end of the gun girder, and the entire gun car is lifted from the trucks a distance of about 4 inches. By means of screw jacks, provided in the bedplate casting of the foundation, it is brought up until it engages with the transom-bedplate casting of the gun car and the load of the car rests upon it. The girders, carrying the railroad track, are then moved to either side of the center line of the track, leaving a clear space in which the gun may recoil. Screw jacks are placed under the heels of the girder to prevent side sway and the 100-ton jacks are removed from the forward jacking beams, allowing the entire weight of the gun car to rest on the foundation and rear jacks. The gun is now ready to fire.

Accurate aim, when firing from the rails, is obtained by firing from a curved track, a change in position of the gun car along the track causing a corresponding change in the azimuth of the gun. When firing from the pit, however, this is not possible. Accurate aim of the gun on the foundation is secured through a traversing gear, which permits the entire gun girder to be swung about the forward transom bed-plate pivot through a horizontal angle of 5°, 2½° on each side of the center line of the tracks. As this angle of traverse represents a deflection on either side of the center line of 500 yards at a range of 23,000 yards, corresponding to an elevation of 15°, and correspondingly greater deflections at greater elevations, it is evident that this angle of traverse is ample for all purposes.

The traversing gear is simply a worm shaft turning in a bearing, cast integral with the rear H jacking beam, and operating against the girder. It is operated by ratchet wrenches, and it has worked with entire satisfaction.



14-INCH RAILWAY GIRDER ON TRUCKS READY FOR TRANSPORTATION TO SHOPS.

STATIONARY BOILER PUT IN OPERATION AT ST. NAZAIRE FOR FURNISHING POWER FOR COMPRESSED AIR FOR ASSEMBLING THE 14-INCH RAILWAY BATTERIES.

BARRACKS ERECTED BY MEN OF THE U. S. NAVAL RAILWAY BATTERIES. 150-TON CRANE IN THE BACKGROUND.

INSIDE OF TEMPORARY BARRACKS FOR CREWS OF U. S. NAVAL RAILWAY BATTERIES.

The loading of the gun is accomplished with an ingenious device consisting of a roller-bearing "trolley-car mounted on an inclined I beam," the lower end of which is placed level with the breech of the gun when the gun is in loading position, level. The 1,400-pound projectile is brought from the ammunition car on a monorail hoist and placed on this trolley. The loading crew then grasp handles at the sides of the trolley and run the length of the car with it. The car is brought to rest against hydraulic buffers at the end of the I beam, while the momentum of the shell is sufficient to carry it the length of the powder chamber and into the bore of the gun, where it is brought to rest by the forcing of the copper rotating band into the rifling of the gun.

The entire gun car is sheathed in one-quarter-inch armor plate. A small combination gas-engine-driven air compressor and winch is placed on the forward truck of the gun car.

THE LOCOMOTIVE AND AUXILIARY CAR OF THE BATTERY.

The problem of the design of the locomotives and the auxiliary cars of the battery was much simpler than that of the gun car.

The locomotives decided upon as necessary for the work of handling the entire train of cars, including the gun car, are standard, consolidation type locomotives, 1–4–4, equipped for operation on French railways.

As mentioned above, among the points insisted upon was this, that standard United States railway material should be used as far as possible, and only absolutely necessary modifications introduced. Only in this way could material be produced in time, or, in fact, could it be obtained at any time during the war. Manufacturers had no time for extensive changes of design. Consequently, all the cars of the expedition were built fundamentally from American design, but with French operating devices, track gauge, and tunnel heights.

THE AMMUNITION CARS.

The ammunition cars are standard steel frame box cars of 60,000 pounds capacity. The roof is covered on the outside, and the sides are lined on the inside with armor plate, similar to that which covers the gun car. Doors are placed in the ends of the cars, and a monorail trolley hoist is provided for handling the 1,400-pound shell and the powder tanks, so that ammunition may be delivered directly to the loading device in the gun car. Each car has racks built to hold a total of 25 shell and 25 charges of powder (50 280-pound tanks). The ammunition cars, as well as the other auxiliary cars, are equipped with air brakes.

The construction cars are standard flat and gondola cars, with the exception of the crane car, which mounts a 10-ton pillar crane provided with a counterbalance. The radius of the boom is 21 feet.

The berthing cars are box cars provided with folding berths. These berths are placed in tiers of three each and supported by the side of the car.

The traveling machine shop is of special interest. It is equipped with a gasoline-engine-driven generator, which supplies current to operate individual motor-driven machine tools placed in the car. This car contains a good-sized lathe, drill press, grinder, forge, and work bench, so that ample facilities are provided for the repair of practically any breakage likely to occur to the guns in service.

In the light of the great speed made in the drafting-room work on this project, it would seem not unlikely that there would be a sacrifice in accuracy of detail, thus making changes necessary during the construction of the mounts. Not so with this work. Not a change was made that caused one minute's delay in the work of construction or assembling. The mounts were built exactly as designed and worked successfully.

THE EXECUTION OF THE PROJECT.

The story of the construction of the 14-inch railway mounts indicates the Nation's patriotic speed in manufacturing, machining, and assembling material during the war. The most satisfactory feature of the entire project was the manner in which the entire equipment fulfilled all the hopes of the persons who had to do with its construction.

The problems to be solved have been outlined in the preceding pages. In addition to the actual work of construction, a large amount of entirely new and important data had to be obtained by special experimental work. A third problem lay in the securing and training of personnel to operate the mounts when completed; a fourth was found in the task of handling the enormous weights and shipping them abroad for reerection in France; and a fifth in the actual work of assembling and reerection in France. The solutions of these problems were carefully thought out and the work systematized so as to allow no "choke points" to form, the result being that the mounts were completed ahead of time and the other phases of the work were in step. The first mount was successfully proved at Sandy Hook on April 30, 1918.

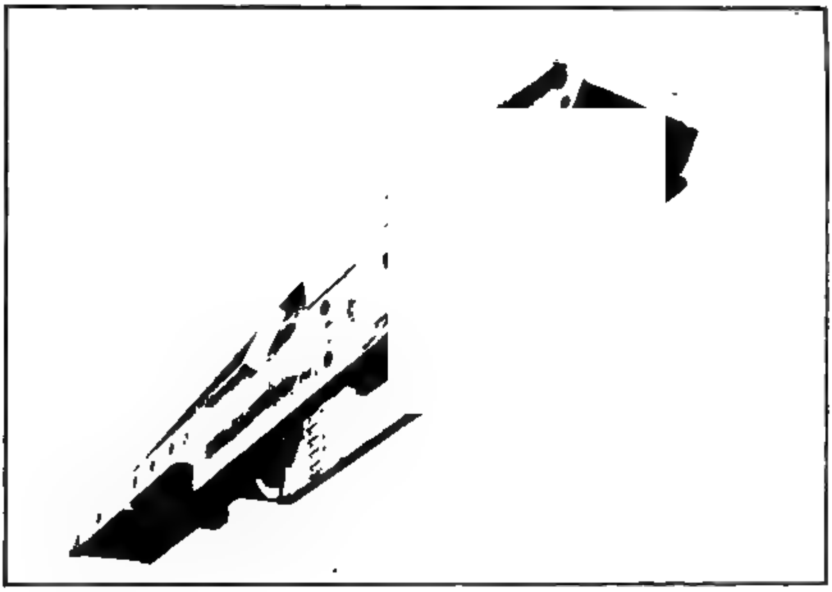
THE FABRICATION OF THE 14-INCH NAVAL RAILWAY BATTERIES.

Immediately following the completion of the designs on January 25, 1918, proposals were sent out by telegraph to the leading bridge builders and manufacturers of railway equipment throughout the

ASSEMBLING TRUCKS FOR CARS OF THE U. S. NAVAL RAILWAY BATTERIES, ST. NAZAIRE, FRANCE.

TRUCKS FOR 14-INCH RAILWAY BATTERY GUN CARS LINED UP ALONGSIDE OF DOCK AWAITING UNLOADING OF GIRDERS.

The girder is wheeled to the shop by placing it directly upon these trucks.



UNLOADING 14-INCH NAVAL RAILWAY BATTERY GIRDER AT ST. NAZAIRE, FRANCE.

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country with facilities for handling the work, calling for an opening of bids on the morning of February 6, 1918, 10 days later.

From the first, it had been determined that the construction of these mounts would not be allowed to interfere with any work under contract for the United States Army, or with other Navy projects under way. This, of course, greatly curtailed the possible sources of supply for the naval railway battery material, for most of the leading locomotive builders, large machine shops and car construction companies were already working to 100 per cent capacity and had many months' orders on their books. When the bids were opened on the 6th of February, a number of offers to undertake the manufacture of the material were received, but they were not satisfactory, principally because the bidders had not appreciated the full significance of the project, and the dates of delivery set in their estimates were too far distant.

At the first opening of bids, however, representatives of the leading railway-equipment manufacturers of the country were present in person. Over the conference table and behind closed doors, the plans were explained to them. They asked for time to go back to their plants to consult with their directors, and accordingly a second opening of bids was scheduled for February 13.

The cooperation of manufacturers in making the project possible was more than pleasing, and at the second opening of bids a number of favorable proposals were received. Among them was the offer of the Baldwin Locomotive Works, made after the insistence thereon of its vice president, Mr. S. M. Vauclain, without whom the Navy guns would never have operated in France, to undertake the construction of the gun cars and locomotives, on a promise to deliver them about the 15th of June. Similarly, the Standard Steel Car Co. offered to undertake the entire work of constructing the 72 cars that were called for. By distributing the order among their various plants, they were able to promise delivery in from 100 to 120 days. After consideration of all the bids these two were found to be the most favorable, and the contracts were awarded on the same afternoon. On the same evening, the work was commenced on the preparation of the material.

Every war seems to have its one outstanding achievement in speed. During the Spanish-American War, all records were broken by the U. S. S. *Oregon* in steaming from the Pacific coast to Cuba. In the Boer War a famous gun, "Long Cecil," was built at Kimberley in 23 days. In this war, the first 14-inch railway mount was completed in 72 days following award of the contract—120 days following the commencement of the first preliminary designs.

From the moment that the bids were accepted and the contracts awarded the fabrication of material moved rapidly forward. Of

course, a delivery schedule was laid down. The most optimistic man at the Baldwin Locomotive Works, Mr. Vauclain, made it out himself, only to have it bettered. The first mount, scheduled for delivery on May 15, 1918, rolled out of the Baldwin locomotive shops complete and ready for firing on April 25, 1918. The last mount was scheduled for June 15 but was finished May 25.

There were no changes in design to delay construction. Plates for the girders were rolled at Pittsburgh and rushed to the American Bridge Co. fabricating plant at Pencoyd in special cars, with Navy men perched on top of them, to see that they got through on time. The first girder unit was received at the Baldwin shops within one month after the order was placed. Meanwhile the work of constructing the trucks for the gun cars at the Baldwin plant, at Philadelphia, was progressing rapidly, and at the Simonds Manufacturing Co. plant, at Fitchburg, rolling of the armor plate was started. As fast as armor plate was completed and tested it was loaded on the Federal Express at Boston and brought through to Philadelphia without change of cars. The gun slide, deck lugs, and elevating gear were machined by the Washington Navy Yard in record time, and where freight cars were not available to carry parts from the yard to Philadelphia auto trucks made the trip. In fact, every conceivable method of transportation was used in seeing that material from contractors reached the Baldwin shops on time. Express cars, baggage cars, freight cars, auto trucks, special messengers, and even suit cases were pressed into service. Notwithstanding bad traffic tie-ups and some of the coldest weather and heaviest snowfalls that have been experienced in the Eastern States in many years, material got there, and got there on time.

While one end of the Baldwin shops was engaged in erecting the gun cars, the other end was erecting the locomotives for the expedition. At the plants of the Standard Steel Car Co., located at various places throughout the country, fabrication of the cars was pushed so that they too were finished in advance of their delivery schedule. In spite of a severe fire and wind storm, which destroyed a considerable portion of one of their large western plants, the contract was completed and the cars delivered by June 1. The start of a complete train load of material from the Hammond, Ind., plant of the Standard Steel Car Co., destined for overseas' shipment as part of the expedition, made an interesting picture.

THE SHIPMENT OF THE RAILWAY MOUNTS.

The original intention of the Bureau of Ordnance was that these mounts should be used in defense of the channel ports of France, operating with the British Army. But conditions as they existed

14-INCH NAVAL RAILWAY BATTERY FIRING FROM FRENCH BATTLE FRONT, OCTOBER, 1918.

EX-GERMAN BOMB PROOFS OCCUPIED BY NAVAL RAILWAY BATTERY NO. 1, NEAR SOISSONS, OCTOBER, 1918.

RAILWAY CROSSING IN LAON, TAKEN FROM AN AEROPLANE.

1,400-POUND PROJECTILES USED WITH 14-INCH NAVAL RAILWAY BATTERIES.

in December, 1917, and in April, 1918, were quite different, and it was impossible at the latter time for the British to name a port of debarkation to which the material could have been started as early as April 15, for enormous quantities of material had accumulated at the Philadelphia Navy Yard, the designated shipping point for the batteries. By May 15, with the completion of the project actually in sight, and but two weeks distant, the batteries were offered to Gen. Pershing for use with the American Army in France, and with the French Army. Gen. Pershing's acceptance was immediate; a cablegram was received asking for shipment of the material as soon as possible, and naming St. Nazaire, France, as the port of debarkation. Preparations to ship the material there were immediately effected.

The shipment was not accomplished without difficulties. The first ship assigned for the work of transportation was badly battered by storms on her western trip and forced into dry dock for repairs. The second ship assigned was the *Texel*, which was one of the first ships sunk by the German submarine *U-151* operating off our coast. Finally, however, the steamship *Newport News*, deeply loaded with material, sailed from Philadelphia on June 29, and other ships followed shortly thereafter.

THE ERECTION OF THE 14-INCH RAILWAY MOUNTS IN FRANCE.

The personnel for the naval railway batteries was ordered abroad as soon as the port of debarkation was fixed, sailed immediately on a troop transport, and arrived at St. Nazaire on June 9, 1918.

For the work of assembly in France, the bureau selected Lieut. Commander D. C. Buell, R. F., an officer of railroad experience, who had watched, as an inspector, the progress of the work at Baldwin's. This officer accomplished his work abroad in record time, despite the fact that all blue prints were lost en route.

St. Nazaire had two great advantages for the erection of these batteries, viz, a 150-ton crane at one of the docks, and French locomotive shops only a quarter of a mile away, equipped with two 125-ton cranes. Outside of the locomotive shops there were a number of tracks available for the erection of the cars of the expedition, and for the finishing touches on the gun cars, after the heavy lifts had been accomplished in the locomotive shops. Two or three miles away were located the Montoir storehouses, in which space was available for the storage of tools, materials, etc., for the batteries. The Nineteenth United States Engineers were located at St. Nazaire, erecting locomotives for the American Expeditionary Forces.

During the first week following their arrival, the men of the battery were busy erecting barracks for their use, a site for which was

obtained close to the erecting tracks. The barracks were made entirely by the bluejackets from scrap lumber from locomotive packing cases. The tracks on which erection was to take place were then rebuilt. A stationary boiler was borrowed, a leaky air pipe line overhauled and compressed air for car erection made available.

After this work there was no Navy work to do, pending the arrival of the first shipload of material. But the men turned to with a vim that surprised everyone. Groups of mechanics were sent to the roundhouse to assist the force there, others went to help the Nineteenth Engineers; still others went to work repairing the tracks in the yards, while switching crews were organized to clear up a congestion of work which had piled up and was delaying erection. The willing cooperation of the Navy men and the spirit of "Do what you can to lick the Kaiser" made them friends everywhere. It was more as a reward for the help they had given than anything else that the Nineteenth Engineers cheerfully consented to loan one of their 35-ton steam locomotive cranes for use during the erection of the Navy material. Only four of these cranes were available at St. Nazaire, and all were in use. Without a crane, rapid erection work would not have been possible.

The *Newport News* arrived at St. Nazaire on July 8. As the material was brought from the hold of the vessel, it was taken to the erection tracks or storehouse and carefully placed in spaces previously laid out for it. A discouraging feature was that, in the first shipload of material, there were practically no complete units on which work might be started, and experience had shown that it was suicidal to attempt work on units for which all material had not arrived. The material had piled up at Philadelphia Navy Yard until it was impossible to separate and ship units, and there was nothing to do but wait for the arrival of the second ship. The second and third shiploads of material both arrived on July 21, and erection work was on in earnest.

One feature is worthy of special mention. The blue prints showing the assembly of all the cars of the expedition were sent by special mail from the United States so that they would arrive at St. Nazaire amply in advance of the receipt of material that they might be studied. Whether they were on a ship sunk by submarine, or how they were lost, will probably never be known. The fact is they never arrived. New ones were ordered by cable from the United States, but by the time they were received the project was within a week of completion. The locomotives were assembled entirely without blue prints.

The heaviest single lift for the crane was the gun girder. This was transported to the shops by placing it directly on the trucks,

which had previously been erected, and hauling it on its own wheels. Only the heavy lifts were handled in the shops, as the cranes were in almost constant use by the engineers. As soon as the deck lugs and gun slide had been placed in a girder, the gun was inserted in the slide, and the gun car was taken to the outside erecting tracks for completion.

The handling of the heavy 14-inch gun presented a problem. It was far too heavy for the light French flat cars, and as there was no heavy wrecking crane available, a breakdown could not be risked. The difficulty was overcome by using the gun girder as a car on which to transport the gun, the gun being laid between the side girders.

The car erection went ahead steadily on the outside tracks. Material had been placed so that a progressive movement of the cars was possible. The trucks were first assembled, and the frames were then placed on them. The sides and roof of the cars then followed, and last of all the interior work. The task of erecting the gun cars was not nearly as difficult as the erection of the seventy-odd cars for the expedition. On no car were there less than 500 rivets to be driven, and on one car there were over 1,200. In this connection there was a handicap similar to the loss of the blue prints. Through some mishap the packages marked "rivets," on being opened, were found to contain stove bolts, and it was necessary to "borrow" rivets from all over France. As the only rivets available were metric-sized rivets, the cars were put together with them. On some of the sizes for which no metric-sized rivets were available it was necessary to draw large rivets down to the proper size by hand. In spite of these difficulties, however, the erection of the cars was not delayed.

All of the work was done under high pressure. There were insistent calls from the front, day after day, for the guns. They were needed, and needed at once. The response of the men to the call is worthy of the highest praise. The working hours were from 7.30 a. m. to noon and from 1 p. m. to 5.15 p. m., but when 5.15 p. m. came around the men would refuse to quit. In the long summer evenings in France it was possible to see up until almost 10 o'clock, and the men insisted on sticking to their jobs, working steadily until it was too dark to see. It is principally to the whole-hearted willing cooperation of the men that the fine record in the assembly of the batteries was made.

The first gun girder was unloaded from the ship and put in the shop on July 30. On August 11 the completed gun car and the first train was ready to leave for the front in response to orders received from the French High Command. With it there was a complete train of cars. The orders to leave were countermanded before the train started, however, and it was not until the 17th that the

first train moved off. It was followed by train No. 2 on the 18th. The last gun car and its train left for the front on September 13; the staff train was completed and moved on the 14th, on which day the barracks at St. Nazaire were evacuated and the storage house entirely cleaned out and turned over to the Engineers. The entire group of naval railway batteries were ready for action on the Western Front two days later.

RECAPITULATION.

Designs started	Dec. 26, 1917.
Designs completed	Jan. 26, 1918.
Contracts let	Feb. 13, 1918.
First mount completed	Apr. 25, 1918.
First mount proved	Apr. 30, 1918.
Fifth mount completed	May 25, 1918.
Overseas shipment commenced	June 20, 1918.
Arrival first shipment at St. Nazaire	July 9, 1918.
Assembly first mount begun	July 26, 1918.
Assembly of first train completed	Aug. 11, 1918.
First train left St. Nazaire for front	Aug. 17, 1918.
First shot fired at front	Sept. 6, 1918.
Final erection and assembly of all units completed	Sept. 14, 1918.

THE OPERATIONS OF THE NAVAL RAILWAY BATTERIES.

In France the naval railway batteries operated as five separate and independent units, all under the command of Rear Admiral C. P. Plunkett, U. S. N. His principal assistants were Lieut. Commanders G. L. Schuyler and J. R. Bunkley. The batteries were commanded as follows:

No. 1 by Lieut. J. A. Martin, U. S. N.
No. 2 by Lieut. (junior grade) E. D. Duckett, U. S. N.
No. 3 by Lieut. W. G. Smith, U. S. N.
No. 4 by Lieut. J. R. Hayden, R. F.
No. 5 by Lieut. J. L. Rodgers, R. F.

The journeys of these guns took them through practically every famous battlefield of the war. Throughout all these thousands of miles of travel the equipment of the batteries stood up well, and the guns operated continuously from the date the first one arrived at the front until the moment when their fire was ceased by the terms of the armistice.

In general, Batteries Nos. 1 and 2 operated with the French armies, while Batteries Nos. 3, 4, and 5 operated with the American Army at Verdun. During the Meuse-Argonne offensive No. 2 Battery was recalled from the French front and with Nos. 3, 4, and 5 kept the main arteries of communication back of the German lines under constant fire day and night. After completing its mission No. 2 was returned to the French.

Prior to the assignment of targets for these guns on the French front the French proved Battery No. 1 at their proving ground at

Nuisemont. They gave this giant gun a target located about 18 miles distant. Four shots were fired and all landed almost within a stone's throw of each other. The French general was so pleased with the result of the firing that he immediately went to Rear Admiral Plunkett and, after congratulating him, said: "Waste no more ammunition, but go and fire it against the Germans." After the proof firing of Battery No. 1 it was ordered to Soissons to commence a bombardment of the railroad yards at Laon. Here for the next 30 days, despite enemy counterfire and the bombs of aviators falling constantly around the gun car, the bombardment of the railroad yards was kept up.

On October 12, after firing a total of 199 rounds, the battery was ordered to cease firing, as the Germans were evacuating the city.

An examination of the former targets of the battery after the German evacuation by officers of the Naval Railway Battery expedition revealed the full extent of the damage done by the shells from this big naval gun. The craters made by the shells were readily recognized from their great and uniform size, and everywhere was seen striking evidence of their destructive power. A large storehouse was seen reduced to utter ruins by the impact of just two of these enormous projectiles, and another case was seen where a large crater had been dug in the railroad switch yards, tying up traffic and demolishing near-by freight cars. The armistice found this gun at Champenoux ready to commence firing upon the enemy.

To Naval Railway Battery No. 2, commanded by Lieut. (junior grade) E. D. Duckett, United States Navy, goes the proud distinction of having fired the first American shell from an American gun manned by American gunners at the Germans on the western front in the World War.[1] On September 6 from a point in the forest of Compiegne Battery No. 2 fired a shot at Tergnier, an important German railroad center, which was being hard pressed by the Allies. After the first shot the Germans began to evacuate the city, and no more shots were fired.

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[1] "Our entry into the war found us with few of the auxiliaries necessary for its conduct in the modern sense. The task of the Ordnance Department in supplying artillery was especially difficult. In order to meet our requirements as rapidly as possible, we accepted the offer of the French Government to supply us with the artillery equipment of 75's, 155-mm. howitzers and 155 G. P. F. guns from their own factories for 30 divisions. The wisdom of this course was fully demonstrated by the fact that, although we soon began the manufacture of these classes of guns at home, there were no guns of American manufacture of the calibers mentioned on our front at the date of the armistice. The only guns of these types produced at home which reached France before the cessation of hostilities were one hundred and nine 75-mm. guns. In adidtion twenty-four 8-inch howitzers from the United States reached our front and were in use when the armistice was signed. Eight 14-inch naval guns of American manufacture were set up on railroad mounts, and most of these were successfully employed on the Meuse-Argonne front under the efficient direction of Admiral Plunkett, of the Navy."—Gen. Pershing's special report to the Secretary of War, December, 1919.

From this position the gun went to Fontenoy-Ambleny and began the shelling of an enormous ammunition dump located by the Germans in Besny-et-Loisy. Thirty-two rounds sufficed to wipe out this ammunition dump. From this point the gun left for Flavy-le-Martel and commenced firing on Mortiers, another important railroad center. Thirty-five rounds were placed in this town, and on October 16 the Germans withdrew. After the withdrawal of the Germans from Mortiers the American Expeditionary Forces sent an urgent request for gun No. 2 and assigned it a position at Charny, near Verdun. The gun was rushed to this point and installed, and, on the day of its arrival, commenced a bombardment of the town and railroad center of Montmedy. Cessation of firing, due to the signing of the armistice, found this gun at Luneville ready to begin operations against Metz.

Batteries Nos. 3, 4, and 5 left St. Nazaire on the 12th, 13th, and 14th of September, respectively, and after a considerable stay at the American Reserve Artillery Base, were given orders to depart for positions near Verdun, from which they were to open fire on the German main line of communications, running from Metz to Sedan.

A glance at the map will show the importance of this target. At that time the battle front around Verdun ran in almost a straight line due northwest. A railroad connecting the cities of Metz and Sedan also ran in almost a straight line, paralleling the front and rendering it very easy for the Germans to shift troops from one point to another all along the lines between these two cities. The Germans had held this battle line for so long that they had brought this railroad to a high state of efficiency. The only alternative line for the transportation of troops from Metz to Sedan was a small and poorly built railroad running almost due north from Metz to Luxemburg City and from Luxemburg City almost due west to Sedan. These railroads formed a right-angled triangle.[1] Should the Americans be successful in cutting the straight line of communication from Metz to Sedan, it would force the enemy to transport troops by the 50 per cent longer route through Luxemburg and over the poorly improved tracks, etc., of the longer railroad. From this it may be readily appreciated why a captured German document referred to the Sedan-Metz railroad line as "the most important artery of the army of the west."

The city of Longuyon was a detraining point on this Metz-Sedan line, containing a main railroad yard with 15 long sidings and

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[1] One of the most prominent of the enemy commanders, Ludendorff, writing of the trench warfare on the western front states his point of view that large numbers of heavy flat trajectory guns such as these Navy 14-inch 50-caliber guns are essential, "as fire falling well into the back areas had been found very effective, rendering supply and relief to the front lines more difficult, and during actual operations hindering the distribution of orders and the employment of reserves."

FIELD NEAR SOISSONS, SHOWING PART OF 12-KILOMETER FIELD TELEPHONE LINE BETWEEN NAVAL RAILWAY BATTERIES NOS 1 AND 2, WITH CONNECTION TO TENTH FRENCH ARMY ARTILLERY HEADQUARTERS. FRENCH THIRD LINE WIRE AND BATTERY OF 75 MILLIMETERS IN BACKGROUND.

NAVAL RAILWAY BATTERY NO. 1 IN POSITION NEAR SOISSONS, FRANCE.

U. S. NAVAL RAILWAY BATTERY FIRING FROM THIERVILLE UPON LONGUYON.

ONE SHOT FROM GUN NO. 1 OF THE U. S. NAVAL RAILWAY BATTERIES, FIRING AT LAON, FRANCE, STRUCK IN THE CENTER OF THE SWITCH YARD AT THAT CITY.

The force of the explosion was sufficient to utterly demolish a flat car which it struck, dig a large crater in the roadbed, tear up the tracks for a distance of more than 80 feet, raise up the wreck of the demolished car over 5 feet and throw it a distance of more than 15 feet, leaving it on top of an adjacent car that was standing on another rail. This picture shows a portion of the crater left in the roadbed by the explosion of the shell.

FREIGHT CAR THROWN ON TOP OF ADJACENT CAR BY ONE SHOT FROM U. S. NAVAL RAILWAY BATTERY FIRING AT LAON.

numerous storehouses. Montmedy had a large railroad yard, which frequently contained 400 cars, was the headquarters of the Seventh German Army, and had large troop barracks and an aviation field. Conflans was also an important railroad and detraining center, having 20 long sidings in the railroad yard and, in addition, a good-sized roundhouse and repair shop. The destruction of these centers could not fail to have an enormous effect on the facilities with which German operations on the western front could be conducted.

Naval Railway Batteries Nos. 3, 4, and 5 arrived at Verdun early in October, were quickly set in position, and commenced firing. The commencement of bombardment by the naval batteries was the signal for an intense effort on the part of the enemy to put them out of action. Shell bursts occurred regularly within 30 feet of the berthing cars and within short distances of the guns themselves. Numerous times the armor plate covering the gun car and ammunition car alone prevented them from sustaining serious damage. In addition, airplanes were frequently flying overhead and dropping bombs.

Up to the arrival of the naval railway batteries, these important troop and railroad centers on the Metz-Sedan line held by the Germans had been immune from artillery fire, for they were several thousand yards beyond the range of the biggest of the allied guns. The arrival of the naval railway batteries in France was one big stroke in the stemming of the German tide, and contributed largely to the consternation created in the German forces by the vigorous tactics of the Americans.

Despite all the fury of the German counterattack, a constant bombardment of targets of Longuyon and Montmedy was maintained by the naval railway batteries. Battery No. 3 selected as its particular target the Longuyon aviation hangars and field; Battery No. 4, the railroad tunnel at Montmedy and the Montmedy yards; and Battery No. 5, the railroad yards at South Longuyon. On November 3, Battery No. 3 was moved to Charny and took for its target the freight yards at Montmedy. On November 4, an airplane observer reported the entire lower Montmedy freight yards on fire. Two days later, it was determined officially and so credited that the shells from Battery No. 3 had accomplished this work.

There was no let-up in the steady fire of the naval batteries at their respective targets until the last moment before the armistice went into effect. Battery No. 4 fired its last shot at 10.57.30 a. m. on the morning of November 11. This permitted the shot to land a few seconds before 11 o'clock.

From reports received later from Allied prisoners and civilians within the territory under fire, it is evident that traffic on the railway running through Longuyon, Montmedy, and Conflans was at all times seriously hampered and for many days was entirely tied up,

forcing the Germans to use the roundabout railroad line running north through Luxemburg and then west to Sedan. When the area was examined by officers of the battery, many places were found where the railroad tracks had been completely severed for a distance of from 40 to 70 feet—the diameter of a 14-inch shell crater. It was reported, in addition to the fire in the yards previously mentioned, that a troop train in motion carrying many Germans had been hit and completely demolished.

In the operations at Verdun, little airplane observation was available. The officers of the expedition, however, developed a system of firing by which shots were placed in a spiral around the designated target, so that even without observation of shots the probabilities of a direct hit were very great.

Official recognition of the importance of the work of the railway batteries at Verdun can be found in the report of Gen. Pershing in his description of the last phase of the Meuse-Argonne offensive, which says:

> Our large caliber guns had advanced and were skillfully brought into position to fire upon the important lines at Montmedy, Longuyon, and Conflans. * * * The strategical goal which was our highest hope was gained. We had cut the enemy's main line of communications, and nothing but surrender or an armistice could save his army from complete disaster.

Also, in his letter to Rear Admiral Plunkett, written after the signing of the armistice:

> Permit me to express to you and to the contingent that served the naval guns under you my sincere appreciation of the very efficient manner in which they cooperated with the artillery of the A. E. F.
>
> Your command has performed a distinctly important service, and I found you at all times eager to carry out our plans in a true spirit of cooperation.
>
> I should be very glad to have you express to all concerned my sincere thanks and appreciation for the work accomplished.

Following the signing of the armistice, all the equipment of the naval railway batteries, with the exception of the gun cars, was turned over to the Army for use in demobilization work. The gun cars themselves were disassembled and returned to the United States, where they are now awaiting future service, as coast defense guns or for the defense of some of our island possessions.

RAILWAY MOUNTS FOR 14-INCH 50-CALIBER GUNS BUILT BY THE BUREAU OF ORDNANCE FOR THE UNITED STATES ARMY.

The first gun car of the naval railway batteries was proved on April 30, 1918. There had been many who had predicted that the test would be a failure, because they did not see how the gun could work properly. Results of the first test were more than convincing and so, on the return trip from the proving ground on April 30,

1918, a verbal request was made by high officials of the Ordnance Department of the Army to have the Navy undertake to construct three additional gun cars, beyond the five under contract for the naval railway batteries, for the Ordnance Department of the United States Army. This was officially confirmed some days later and a formal order placed with the bureau by the Ordnance Department for the construction of three of the 14-inch gun cars.

This order was placed by the bureau with the Baldwin Locomotive Works, who were constructing the gun cars for the naval railway batteries, during the first few days of May, 1918. The mounts built for the Army were exactly the same in every respect as those constructed for the Navy for its own expedition, and the work of inspection and certification was carried on by the Navy's staff of inspectors.

Work was carried forward on the mounts constructed for the Army at the same pace set on the construction of the naval railway battery gun cars, so that the material took shape rapidly. The first of the three gun cars, ordered by the United States Army in May, was delivered early in July, the second a few days later, and the third was completed and placed on the docks ready for foreign shipment by the Army Ordnance Department on the 18th of July, 1918. With the completion of the first three mounts constructed for the United States Army, actually in sight and but a few days distant, early in July the Ordnance Department placed an order for a second set of three mounts, making a total of six constructed for them. These mounts were identical with the first eight built. The order for these was similarly placed with the Baldwin Locomotive Works.

The organizations of the various contractors who manufactured materials for these gun cars had, by the time the eighth mount was completed, become so expert in the fabrication of this heavy material that still another record was set in the manufacture of the ninth, tenth, and eleventh gun cars. Fabrication of the material started late in July; the three mounts were completed and ready for shipment by the 20th of September, 1918. It had been thought that the record of 72 days from the date of first orders for material to final fabrication and placing on the docks of the Philadelphia Navy Yard for shipment abroad could not be bettered, but on this second order for three mounts for the Army that time was cut by nearly 20 days.

In addition to supplying the six gun cars for the Army, the bureau supplied two ammunition cars for each gun car, in all respects identical with the ammunition cars supplied for the naval railway batteries. These cars, as noted before, were large box cars fitted with frames and racks for carrying the shell and powder, and were sheathed with bullet-proof steel in a manner similar to the gun car. The Navy agreed to supply all the necessary ammunition and

powder for placing all the gun cars constructed by it for the Army in active service in France. This ammunition was assembled, loaded, boxed, and made ready for shipment at the naval ammunition depot at Fort Mifflin, Pa., and was subject to the orders of the Army authorities. In addition, spare parts for the gun cars necessary for the operation of the gun were furnished.

LATER DESIGN OF THE NAVAL RAILWAY BATTERIES.

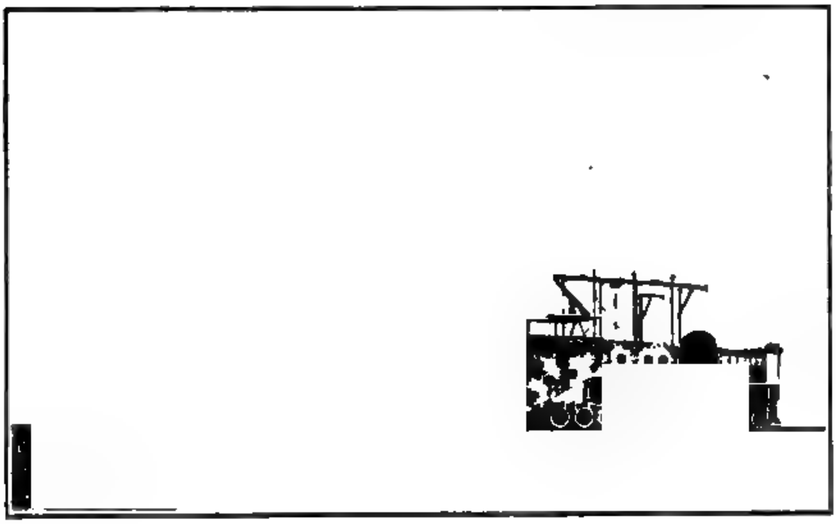
In the design of the railway mounts or gun cars which comprised the fighting units of the naval railway batteries, the vital consideration underlying all principles of design was the factor of time. The naval railway batteries were needed in France, not in 1919 or 1920 but by the summer of 1918, in order that they might do their most effective work, and help, when help was needed, in bombarding the Germans. It was natural, therefore, that when there were two good methods of solving a problem of design that the one offering the least difficulties in the nature of construction, etc., should be followed. For this reason the original Navy gun car designed and constructed by the Bureau of Ordnance made use of as much standard Navy material as possible and followed to the fullest extent standard Navy practice that was sure to work.

The difficulties in connection with taking care of the recoil of the gun have been explained and the method for overcoming them. The factor of time, probably more than anything else, influenced the decision to build a gun car capable of firing at elevations up to 15° directly from the rails, and from a pit foundation at elevations above 15° up to the maximum of 43°. This type of construction permitted the use of a number of standard Navy parts already completed or in process, thus saving the time required in machining them.

As soon as the naval railway batteries were in successful operation in France and their great value was known, the Bureau of Ordnance took up the question of building a gun car capable of mounting a 14-inch 50-caliber gun and permitting it to fire at all elevations up to a maximum of 43° directly from the rails. This type for some reasons might prove better than the type in operation which necessitated a pit, yet it is not certain, however, that this change will be actually an improvement.

Accordingly, early in October, 1918, Navy designers acting on orders received from the Chief of the Bureau of Ordnance, commenced work on the design of such a gun car.

The problem of railway clearances, that is, of getting the gun and mount through the French tunnels, made the design a difficult, though not impossible, task. In order to come within the limits of



14-INCH RAILWAY MOUNT, MARK II, AT MAXIMUM ELEVATION. NO PIT IS REQUIRED FOR THIS MOUNT

14-INCH RAILWAY MOUNT, MARK II. GUN IN BATTERY.

14-INCH RAILWAY MOUNT, MARK II. GUN HOUSED TO GIVE SUFFICIENT HEADROOM WHEN PASSING THROUGH TUNNELS

these clearances, and yet permit the gun to fire at angles of elevation up to 43° directly from the rails, it was necessary to transport the gun in a lowered position between the gun girder and then raise it by some means into firing position, so that the breech of the gun would not interfere with the rails on firing. It was impossible with this gun merely to dig a pit between the rails because the breech end of the gun has a greater diameter, by over a foot, than the standard track gauge.

A number of proposed means for elevating the gun into firing position had been investigated and considered, among them the idea of raising the gun with its mount up in the gun girder by means of screw jacks, another the idea of firing the gun into position, that is, of utilizing a portion of the recoil energy of the gun to raise the entire gun. All of these, and several others, were found impracticable, and it was finally decided that the only sure way of meeting the conditions imposed was to build the gun and its supporting and recoil mechanism into a single unit, raising this unit from traveling position into firing position by means of hydraulic cylinders.

As soon as the general designs for the gun cars had been worked out and nothing but the preparation of detailed drawings remained, the contract for the construction of an initial order of five of this new type of gun car was awarded to the Baldwin Locomotive Works on a basis of cost-plus-fixed-profit.

At the time this work was under way, the drafting-room forces of the Bureau of Ordnance and the Naval Gun Factory were very much overloaded with work. It was, therefore, arranged that the drafting-room force of the Baldwin Locomotive Works should undertake the preparation of the detailed plans for this new gun car, acting under the direct supervision of designers sent from the Bureau of Ordnance to take charge of the work.

The enthusiasm due to the records made by the Baldwin Locomotive Works in the construction of the original naval railway batteries was still with the drafting-room force of that company, and work on the designs of this new gun car was pushed with a vim. A few experienced Navy designers, in addition to those supervising the work, were sent to Philadelphia from the Naval Gun Factory to work out the purely ordnance features of the design, while the Baldwin Locomotive Works designers worked on the railroad and car features. The combination of work and the results achieved far exceeded all expectations, for with a rapidity not dreamed of the designs took shape. The work was so planned that detailed drawings for material required to be manufactured by outside contractors and special material were finished first. Thus all drawings for plates, which had to be rolled by the plate mills, and for steel castings, patterns for which had to be manufactured before the castings

themselves could be made, were ready for issue within a week, and, before any of the minor details had been touched, orders for the larger items of material and those requiring the longest time for manufacture had been placed. Following this, work was continued on the smaller items and material orders placed for these as well.

By the end of October, work was underway and, at various manufacturing plants here and there throughout the country, it was going forward every minute of the 24 hours in the day. It was expected, on November 1, that the first of these gun cars would be ready for proof and shipment abroad by the 1st of January, 1919, and that the other four would follow within a few weeks thereafter, so that by the 1st of March, 1919, a battery of five of these weapons would be in action on the western front.

The signing of the armistice, of course, cut short the urgent necessity for this material. Such progress had been made, however, that it was decided to proceed with the construction of two of these gun mounts, canceling the order for three of the five originally contracted for, and work on these two was slowed up as much as practicable.

The first of these gun cars was completed on July 17, 1919, and a few days later was transported by rail to the Naval Gun Factory, Washington, D. C., thence by barge to the Naval Proving Ground at Dahlgren, Va. At Dahlgren, on the morning of August 5, 1919, in the presence of Army and Navy officials and prominent engineers, the mount was tested. Everything functioned perfectly—not the slightest trouble was experienced in firing. It was demonstrated that the gun could be run to the firing point, traveling over railroads at a speed of as much as 25 miles per hour, and within six minutes after its arrival at firing point be ready to fire its first shot.

The new Navy gun car has a wheel base of about 83 feet, and as the gun overhangs the forward end and the cab the rear end of the car somewhat, the total length is not far from 110 feet. It weighs the enormous total of 610,000 pounds, or 305 tons, and is supported on 40 wheels.

THE FUTURE USE OF OUR RAILWAY GUNS.

All of the railway guns constructed by the Navy for service in France during the war are now in the United States, and they have been delivered to the War Department.

They form a most valuable gun for coast defense, for they are equal in size to any gun now afloat on any warship in the American Navy (but few in foreign navies have guns larger than 14-inch caliber) and, by reason of their 40° angle of elevation, they outrange the guns of any warship in existence.

The designers of the bureau have worked out a plan whereby simple emplacements can be manufactured for these guns and set up in the field. The guns can then be placed upon them, jacked in place, and become the equal of a gun on a fixed land emplacement. These field foundations on emplacements are so designed that an all-round angle of fire can be obtained, that is, the mount can be traversed by hand through the entire circle of 360°.

If desired, several emplacements or turntables for these guns may be prepared at strategical points and, when it is desired to use the gun at any one of them, a locomotive can be coupled to the gun car and the entire gun and its mount quickly moved to the desired point. One of these railway mounts, therefore, becomes the equal of many fixed guns for coast defense.

The improved type of railway mount, or the "railway gun car Mk. II," which fires at a maximum range directly from the rails, does not, of course, need a turntable arrangement, or any other preparation other than the installation of a curved track. This makes this gun, as well as the original type of naval railway gun, an extremely valuable coast-defense weapon. It is only necessary to provide a curved track to permit the gun to fire in any direction.

Any of these railway mounts can be moved from one coast to the other on very short notice. On almost instant demand, a locomotive can be coupled to them, ammunition cars and all material needed for operation coupled on behind, and the entire outfit can start for the opposite coast within a few hours. They can make the transcontinental trip at a speed of 25 to 30 miles an hour and arrive at their destination within a week's time.

CHAPTER XIV.

TRACTOR BATTERIES.

A great need of our Army in France during the year 1918 was for artillery. The cry of our forces in France was always for guns, guns, and still more guns. Although the British and French factories were doing their utmost to supply the American Army in France with ordnance material during the period required for the plants in this country to get into production and quantity manufacture, there was still a dire need for ordnance. In particular, the cry was for heavy and high-powered mobile ordnance, such as a major-caliber field piece with a range of 20,000 yards or so; that is, a field piece that could travel over any country over which the standard artillery tractor could go, and could be transported from place to place without disassembling.

All large field guns in use by the British, French, and Italian armies as well as many smaller and less powerful guns and howitzers were only semimobile—that is, they were so constructed that in order to transport them the entire gun and mount had to be taken apart, the pieces loaded on separate trucks and transported as separate units, making it necessary for them to be reassembled before fire could be recommenced. Several hours of hard work, of intensive preparation and reassembly, were necessary, therefore, before a gun of any size could be made ready to fire after arriving at the firing point. There was no such thing as a really high-powered, large-caliber field piece that could be transported to the front at a moment's notice and would arrive there ready to commence fire on the enemy.

Almost by chance, in the spring of 1918, a number of 7-inch 45-caliber naval guns became available for service. These guns had been removed from battleships of the *Connecticut* class. These battleships, when built, were provided with a secondary battery of 7-inch 45-caliber guns mounted between decks. These 7-inch guns gave excellent service and were a good selection for the work that was expected of them until the war broke out and ships of this class were assigned to convoy service. In this service a light, quick, and hard-hitting gun was needed. Further, the ships were required to be as nearly torpedo proof as they could possibly be made, for no one knew when a torpedo or mine might be encountered. Experiences of tor-

pedoed war vessels clearly demonstrated the danger of having wide gun-port openings near the water line, and ships of the *Connecticut* class were at fault in this respect, in that the mounting of these heavy 7-inch guns between decks left wide openings in the sides of these vessels, so much so that should a heavy list lower one side of the ship an inrush of water sufficient to capsize the ship might be expected. In view of these facts, the department decided to remove the 7-inch guns from between decks on these battleships, permanently sealing the gun ports, and mounting smaller guns one deck higher.

These 7-inch guns were too heavy for installation on armed merchantmen. But no guns in time of stress should be unused. Therefore the chief of bureau, having in mind the need for a really mobile field mount in France and knowing that the 7-inch guns were available for this service, ordered the Naval Gun Factory, early in March, 1918, to prepare designs for mounting and placing in action on the western front a battery of these 7-inch guns.

The 7-inch guns removed may be described about as follows: The gun, with breech mechanism, weighs 28,700 pounds, or about 14 tons. It is 45 calibers, 315 inches, or about 26 feet long, and gives a 153-pound shell a muzzle velocity of 2,700 feet per second. At a range of 14,000 yards the shell has a remaining velocity of 1,250 feet per second and can penetrate several feet of concrete or earthworks. The shell carries a bursting charge of 24 pounds of TNT. Its maximum range at an elevation of 40° is in the neighborhood of 24,000 yards.

On board ship the mount for the gun weighed nearly 30,000 pounds, so that the total weight of the gun and mount was not far from 30 tons. When the gun recoiled after firing, the maximum trunnion pressure exerted was about 195,000 pounds. A hydraulic brake took up the recoil through a distance of 21 inches, and the gun was brought back to battery or firing position in the usual way, by means of heavy helical springs contained in spring cylinders attached to the slide in which the gun operated. The mount was designed to allow a maximum elevation of the gun of 15°, which allowed a range of about 14,000 yards.

Early application for a number of these guns was made by the United States Army, and those requested were delivered. The guns, thus turned over, were mounted by the Army on railway cars. Special cars were used for this purpose, built with a drop-frame bed, so that the entire 7-inch gun and its mount, exactly as it was used on board ship, could be placed on it and yet clear the French tunnel roofs, when in transit. These were not put in operation abroad.

7-INCH GUN ON CATERPILLAR MOUNT (WEIGHT, 76,000 POUNDS) ON FIRING POSITION. BREECH OPENED, GUN READY TO LOAD.

7-INCH GUN ON CATERPILLAR MOUNT.

7-INCH TRACTOR MOUNT FROM PEN AND INK SKETCH.

PROOF FIRING OF THE 7-INCH CATERPILLAR MOUNT

The railroad mount was limited in its use by the fact that the elevation limit set by conditions on board ship was still maintained; that is, the gun was still capable of a maximum elevation of but 15° with its corresponding range of 14,000 yards. Further, the heavy trunnion pressures existing on account of the short length of recoil of the gun, while entirely satisfactory on board ship, where the structure of the vessel is built to stand them, were troublesome when the mount was placed on a railway car. Strong outriggers and bracing of the car and bed were required when the gun fired at targets at an angle to the line of the track on which the gun car was located.

When considering the best way to place these guns in the war, the bureau first gave attention to the plan of mounting them on railway cars. It set to work to increase the permissible angle of elevation from 15° to 30°, feeling that this was the minimum. The designs were soon completed. They called for the mounting of the guns on a special flat car, the bed of which was not dropped, but which had a heavy underframe so that no bracing of the car, other than a few light outriggers, would be necessary when the gun fired. This called for the construction of a new mount in which the maximum elevation of 30° was possible, and in which the trunnion pressure was reduced to about 65,000 pounds. In the new mount, the recoil was used to elevate the entire gun up an inclined runway, in addition to overcoming the resistance of the hydraulic brake.

Word was received from abroad, while these designs for a railway mount were being completed, that better use of these 7-inch guns could be made if a suitable field mounting were developed for them. Work on the design of a mobile field mounting for the 7-inch gun was therefore immediately started at the Naval Gun Factory, March 15, 1918.

The Bureau of Ordnance was confronted with a problem which can be outlined about as follows:

A mobile mounting was desired for a 7-inch gun weighing 30,000 pounds—a mount that would allow the gun to be transported as a unit, so that no preliminary preparation was necessary before firing. The 7-inch gun was the heaviest and hardest hitting gun for which a mobile field mount of this kind had ever been requested by any nation or army. The mounts were wanted in France before the close of the year 1918—a date less than nine months distant—so the time for design and construction was short.

With these conditions in mind, the gun designers of the Naval Gun Factory proceeded to study existing designs of field artillery that were available.

The development of these tractor mounts was carried out parallel with that of the 14-inch railway batteries, and consequently was largely under the supervision of the same personnel. Under the direction of the chief of bureau, assisted by Lieut. Commander Bye, the Naval Gun Factory, commanded by Capt. A. L. Willard, prepared the designs for these mounts. Commander Harvey Delano was in immediate charge of the design section of the gun factory, and actual designs were worked out in large part by Chief Draftsmen G. A. Chadwick and S. B. Kemp. Once the design was prepared the mount passed to the production stage at the Baldwin Locomotive Works. Here the energies of the vice president of the company, Mr. S. M. Vauclain, pressed the project through to its early completion, assisted in large part by the cooperation of the bureau's inspectors, Commander A. C. Dieffenbach, United States Navy (ret.); Lieut. G. T. Ladd, R. F., and Mr. John Kindle.

A brief examination of the existing designs showed that a wheeled mount for the 7-inch gun was not practicable. The weight of the gun and mount complete would be in the neighborhood of 70,000 pounds, or 35 tons. Assuming a 6-foot wheel, and an arc of 25° in contact with the ground at any time, the total bearing surface to carry the load would be about 6 square feet, giving a ground pressure of about 6 tons per square foot, or 88 pounds per square inch. This weight was, of course, prohibitive, for the gun, when moving over a road, would probably leave its path marked by broken roadbed, and further, when the piece left the road and attempted to move over soft ground, there was every reason to believe that it would soon become hopelessly mired. Another doubtful point, also, was whether or not a wheeled mount of the ordinary type would prove satisfactory on firing, as wheeled mounts have a tendency to roll back on firing, and the weight of a large wheeled mount makes accurate aiming a difficult task.

A wheeled mount was clearly not practicable for the 7-inch gun, so a search was made for something better. At this point, the idea of utilizing the principles of the so-called "caterpillar" belt for transporting the mount was suggested, by analogy from the tanks then coming into use. Instead of wheels, it was proposed to use a steel frame with rollers carrying a link belt presenting a large flat surface to the ground. Similar material had been used with success on commercial tractors and on adaptations of them, mounting small pieces of artillery, but never a gun mount for a major caliber gun. Yet there appeared no practical objection. Sufficient strength could be given to the construction of the tractor belt, so that it would withstand the stresses brought to bear, and preliminary calculations showed a ground contact area of 28 square feet would be obtained, giving a bearing pressure of about 18 pounds per square inch, which

is about one-half of that exerted by a horse's hoof. Designs were accordingly commenced by the Naval Gun Factory on a mount of this type, to carry the 7-inch gun.

From the ordnance point of view, the greatest problem in field artillery is the construction of a mount which will stand the shock of gunfire, and can be carried over roads and fields. The calculations just described showed that a caterpillar mount would prove serviceable. From the Field Artillery's point of view, however, the moving of the mount from place to place is quite naturally all-important. This mount was not, of course, to be self-propelling; its function was solely to support the weight of the gun during its transportation and its firing. Some further agent must be found to move it. Fortunately, this was not difficult. A rapid survey of the field of farm and road tractors disclosed a very suitable type in the 120-horsepower Holt caterpillar tractor, the largest gasoline tractor built in the United States. This, like the gun mount, operated on an endless belt, and was able to move over roads and fields with the same ease as the mount, and yet to exert sufficient traction to haul the heavy gun wherever it might be needed.

The agent to move the gun decided upon, there remained the detailed design of the mount itself.

In order to save time in construction, it was hoped that it might be possible to incorporate into the caterpillar mount for the 7-inch gun a number of parts of the mount used on board ship, particularly the gun slide and the recoil and counter recoil mechanism. It appeared more logical on considering the question, however, to lengthen the recoil of the gun as much as possible, thus reducing the trunnion pressure when firing and, in turn, the weight of the mount, than to build a heavy mount capable of standing the shock of firing with the short length of recoil set, in the standard mount, by conditions on board ship. Further, the counter recoil mechanism of the ship mount was designed to return the gun to battery at elevations up to 15° only. An elevation of 40° was contemplated in the new land mount, making the design of a new counter recoil mechanism necessary. It was soon found, therefore, that the designers must work from the ground up—every part of the mount had to be newly designed. Only the gun itself, with its breech mechanism and yoke, could be used, of all the material taken from the battleships.

Work on the designs was rushed at the naval gun factory, and, in spite of the great pressure of other work, progressed rapidly. Preliminary designs were submitted within a fortnight. They called for a mount with caterpillar belt wheels, a structural steel carriage, and a gun slide equipped with hydraulic recoil and pneumatic counter recoil systems. These recoil systems allowed a recoil of 32

inches, which reduced the trunnion pressure from 195,000 pounds in the original Navy mount to 120,000 pounds.

Although entirely new, the designs were so carefully worked out, and the engineering facts were so strikingly presented, that immediate approval was given to the bureau by the Chief of Naval Operations to proceed with the designs and construction.

Detail designs were commenced, and on May 25, 1918, these were pronounced complete. One hundred and sixty-four separate drawings were required to show the material.

On May 30, 1918, proposals were sent out calling for bids for the manufacture of material. An initial construction of 20 of these mounts was decided upon. Proposals called for the delivery of the 20 mounts in 120 days.

Although many bids were received, the times of delivery set in most of them were far too long to warrant their consideration. The guns were needed in France, not in 1919 or 1920, but before the end of 1918. On June 18, 1918, therefore, the contract was awarded to the Baldwin Locomotive Works, Philadelphia, who agreed to undertake the manufacture and delivery of the 20 mounts in the time specified; in other words, by October 18, 1918.

Work moved rapidly forward from the first day. Material began to arrive at the Baldwin works within a few days after the contract had been awarded and orders for material placed.

Despite many difficulties in the procuring of material, due to the fact that the manufacturing capacity of the country was at that time, the summer of 1918, practically 100 per cent taken up in the manufacture of other war material, most satisfactory progress was made on the erection of the mounts. Of course, some difficulties were encountered in the construction. It was to be expected that in dealing with such new and untried material, problems of manufacture would arise that might cause trouble. But, in spite of all these difficulties, the plan outlined for the erection work of these mounts was not delayed and the first two mounts, complete and ready to fire, were completed in the record time of 92 days and were shipped from the Baldwin Locomotive Works at Philadelphia on September 26, 1918, just 100 days from the date of the contract.

The schedule of work at the Baldwin Locomotive Works had been so laid out that the remainder of the 20 mounts under contract were due to follow at two or three day intervals after the completion of the first mount. The third mount, accordingly, was completed at the Baldwin Locomotive Works on September 30, and the others were rapidly following.

The first two complete mounts were shipped to Washington, for transmission to the Naval Proving Ground at Indian Head, for road tests and proof firing.

On arrival at the Washington Navy Yard these caterpillar tractor mounts received their first road test. It was necessary to haul them from the railroad tracks to the docks and generally around the navy yard. No tractor being available, it was at first thought that these heavy mounts, each weighing 76,000 pounds, or 38 tons, could not be hauled by anything less than one of the big tractors provided with the battery outfit for that specific purpose. However, to see what would happen, a 3-ton motor truck was coupled to the first mount. It was found that the heavy mount could be moved with perfect ease by one motor truck along level roads. To haul the mount up an 8-per-cent grade, a second motor truck was coupled up and the two trucks succeeded with ease.

The operation of these Navy guns in France was intended to be entrusted to a regiment of United States Marines, assembled for this purpose in the summer of 1918 at the naval proving ground at Indian Head, Md., and also at the lower station of the proving ground at Dahlgren, Va. The bureau was providing a complete outfit of material for the operation of the battery. This outfit included ammunition trucks to carry ammunition directly to the guns on the firing lines, large motor trucks for the transportation of men and supplies, and repair trucks, telephone trucks, ambulances, water trucks, and, in addition to this rolling stock, sufficient quantities of the many hundred items of material that are necessary in order to supply an expedition of this size in the field. In short, the equipment furnished by the bureau to this regiment of Marines was sufficient to enable them to go anywhere in the world and operate as an independent unit or in conjunction with Army or Navy forces. For the specific purpose of hauling the caterpillar mounts, thirty Holt caterpillar tractors were furnished.

A small portion of the material they were to use abroad, that is, one or two of each of the different types of trucks, was furnished to the regiment of Marines in training at Indian Head for training purposes, the balance of the material being assembled at the Philadelphia Navy Yard late in August and early in September, so that by the 1st of October, 1918, much material had accumulated on the docks at Philadelphia, all marked and packed ready for shipment abroad. Indeed, a sufficient quantity had accumulated by September 15 to have warranted the transportation abroad of the Marine personnel of the batteries and the commencing of shipment of the material.

When the mounts arrived at Indian Head for proof and test, the marines were ready for them. They were waiting for the mount, with a tractor ready to roll the mount off the barge when it arrived at Indian Head. As soon as it had been unloaded from the barge it

was given a most thorough road test. With the tractors coupled to the mounts they were pulled up and down hill, over rough and newly made ground, and along hillsides. They proved themselves thoroughly able to negotiate any ground over which the tractors themselves were able to operate. Obstacles were mowed down, and yet the entire weight of both gun and mount was so evenly and well distributed by the caterpillar-belt wheels that no damage was done to roads when it was necessary to traverse them, and even the softest ground encountered was passed over as easily as the most level boulevard. Fifteen minutes' observation of the way in which these mounts could be handled left no doubt in the minds of observers as to their ability to operate most successfully in France. The day following their arrival at the proving ground the guns were proof fired.

It is needless to deny that there was considerable anxiety regarding the results of this test. When the guns were proof fired, however, every expectation of the designers was fulfilled. Although no 7-inch gun in our Navy had ever previously been fired at an angle of elevation of 40°, yet the prediction of the gun designers with regard to range were fulfilled. The range was found to be 24,000 yards. The mount functioned with precision. With but small timbers placed at each end of the caterpillar wheels and a few rough timbers buried in the ground under the trail, the mount remained steady on the point of aim during continued firing. Thus it was not necessary to repoint the gun after each shot, for the mount was as steady as if permanently placed on a concrete foundation. The design of counter-recoil mechanism, which, although using the French idea, was an entirely new adaptation of an old principle, worked without a flaw.

By October 15, five or six mounts were ready for shipment to France, and the delivery of the remaining number of the order for 20 was a matter of but a few weeks. The marines were enthusiastic and ready to start at once, but at this point the only delay in the entire expedition occurred, and, as no embarkation orders were received, time rolled by until on November 11 the armistice was signed, and thus the battery lost its chance to do its part in the field.

At the test of the first 7-inch gun on the caterpillar mount there were present officials of the Ordnance Department of the Army. They were favorably impressed by the efficiency of the new type of mount and were quick to realize the possibilities that this type of construction involved. They saw at once the fact that the bureau had produced a design that represented a distinct advance. They determined to take advantage of the manufacturing organization built up by the bureau and—just as in the case of the naval railway battery gun cars—immediately placed an order with the bureau for

the construction of a number of identical gun mounts for the United States Army. They desired to construct as many mounts as the Navy had guns available to turn over to the Army for the purpose, and, as it was found that the Navy had 36 guns available, the Army asked for 36 of this new type of mount.

Work on the construction of this additional number of 36 mounts was taken up and carried forward at the same high speed as was evidenced in the construction of the material built for the Navy itself, or rather the Marine Corps. By the 10th of October, 1918, orders for material had been placed with the many concerns that were to supply the various parts, and the work was on in earnest. Although no completed gun mount had been delivered on this order for 36 at the time the armistice was signed the work of their construction was so far advanced that it was found possible to cancel only half of the order, in the general reduction of war construction. The manufacture of 18 of these mounts was accordingly proceeded with, the balance of 18 being canceled. The completion of the contracts for the construction of these caterpillar mounts gave the Marine Corps a total of 20 of these guns, and the United States Army a total of 18.

The value of these mobile caterpillar mounts for advanced base work is great. They can be hauled over the open country into the center of any area, and, as they are superior to any field gun in the world, they should form a sure weapon of offense or defense. A battery of thirty-eight 7-inch guns, each gun throwing a 153-pound projectile at a muzzle velocity of 2,700 feet per second, is a battery that must be reckoned with in any operations.

CHAPTER XV.

INTELLIGENCE.

A very considerable part of the work of the Bureau of Ordnance consists in keeping in constant touch with the latest developments along technical lines, particularly such as refer to the activities of the bureau in the production of ordnance material.

There is much to be gained by procuring such information. The progress of ordnance development in all navies follows nearly the same general lines, and the maintenance of a proper information service often saves not only a vast amount of time in the development of ideas, etc., but also a corresponding amount of money in the avoidance of duplication of work. For this reason, in peace times, the foreign nations, as well as we ourselves, closely guard the secrets of their progress and developments, and only here and there may a chance insight into the plans of the other powers be obtained.

Before the war, the service for procuring such material of value to the Bureau of Ordnance was limited, and the amount of work involved was consequently comparatively small. In addition to its other duties, the work of analyzing technical information that might be received was assigned to the turret section. There was no publicity work, as such, carried on.

The outbreak of the war in 1914, culminating in the entrance of the United States into the war in 1917, led to great strides in technical development, and this was naturally reflected by a vast increase in the number of sources available to the United States for the accumulation of information. Officers of the Navy and of the Army, sent overseas after the beginning of the war on trips of observation, were able to secure valuable results of tests and experimental work carried on abroad, which, as an aid to the rapid development of our war facilities, were of much value. The monetary value of the results obtained was a matter of many thousands of dollars, but this was overshadowed by the saving of time and effort due to the fact that the United States was not forced to duplicate work already done by the Allies. The Allies, upon our entrance into the war, freely opened their files for our examination, so that the obtaining of information was, to a large extent, a matter only of knowing what information was desired and asking for it.

In November, 1917, Ensign C. L. McCrea, R. F., was enrolled for intelligence work under the Turret Section, Lieutenant Commander L. B. Bye, in charge. The service of this section developed rapidly, and several enlisted assistants were added.

In the summer of 1918, a second officer, Ensign L. E. Browne, of qualifications suitable for this section, was enrolled to assist in the work.

This work has been divided into three main fields: First, the obtaining of information; second, the analyzing of information received and its proper dissemination among desks and officers of the bureau; and third, the maintenance of confidential files. In addition, the section was entrusted with the investigation of special subjects, the preparation of special reports, and a large amount of statistical work.

In the obtaining of information, the aim has been to gather material of value from all domestic and foreign sources. The Information Section of the Bureau of Ordnance was one of the first organized and devoted to this purpose, and it has seen not only an expansion of its own work but also the formation of similar sections by other bureaus of the Navy Department and by departments and organizations of the United States Army. In addition, several scientific and other bodies appointed committees and representatives for the purpose of securing technical information. The service of these agencies, of course, has not been limited to the field of ordnance, but it has been noted with interest that, due perhaps to the superior organization of ordnance work, both here and abroad, a large percentage of the information collected by them has been along such lines.

Most of the data obtained from abroad has been secured through naval representatives, representatives of the Office of Naval Intelligence, and the Force Commander of United States Naval Forces Operating in European Waters, particularly the ordnance representative on the staff of the Force Commander, Commander G. L. Schuyler, United States Navy. In addition, Navy and Army officers making trips of observation abroad obtained many foreign publications on the respective subjects which they were investigating and also contributed valuable information in the shape of written reports.

The principal agencies with which the Bureau of Ordnance cooperated in the work of obtaining information were:

Office of Naval Intelligence.

Office of Naval Operations.

Army Ordnance and Aviation Information Service.

Other special branches of the Army, including Chemical Warfare Service, Army Engineers, etc.

Information committee of the National Research Council, Council of National Defense.

Bureau of Standards.

Force Commander, of United States Naval Forces Operating in European Waters.

Naval and scientific attachés at London, Paris, Rome, etc.

ANALYZING AND DISTRIBUTING INFORMATION.

Naturally, a portion of the information collected was of little or no value, in spite of efforts to obtain only data of importance. The pressure of work in the bureau called for the elimination of all but accurate and technically valuable data. Accordingly, a very careful sorting process was arranged for the information received, the valuable technical points were separated from reports accumulated, and these only were sent to the various sections of the bureau, with a view to making the service of the information section as efficient as possible.

Information of a general nature, but of interest to the Bureau of Ordnance in particular, was handled by distributing it in the form of a mimeographed bulletin issued from time to time. This bulletin was not only sent to all officers in the bureau proper but was also forwarded to various ammunition depots and inspectors in the field. It served to promote closer relations between the bureau in Washington and the service. Information that was of general interest to the naval service as a whole, as well as to the Bureau of Ordnance, was distributed by forwarding it to the Office of Naval Intelligence, who included it in a semimonthly bulletin issued to all ships and stations of the service, as well as to the various bureaus of the Navy Department. Copies of this bulletin were of course furnished for the Bureau of Ordnance. This method of distributing general information resulted in the minimum expenditure of effort by all concerned and the greatest possible benefit to all.

The result reached by the distribution of ordnance information among the personnel of ordnance stations afloat and ashore is believed to possess such real and tangible value that it is planned to continue the distribution of such information in times of peace. It is found that by keeping ordnance officers informed of progress along ordnance lines in general, and especially as to the nature of proposed developments, they are able to cooperate with the bureau by giving the benefit of their experience in the solution of problems that are constantly arising.

suming that the war continued and that all shipyards for the manufacture of steel ships would be kept operating to capacity during that time. Upon checking these estimates with those prepared by the bureau four months previously it was found that the total number of guns required varied less than 3 per cent.

During the war, there arose the need of a recognized agency for the preparation and distribution of official reports of the bureau's progress, for publication in the press of the country. This work was required to be done in co-operation with the Committee on Public Information representative for the Navy Department. The country was, of course, very deeply interested in the work that the Navy was doing, and, while many of the more confidential developments were necessarily kept secret, still there was a large amount of data available for issue to the public.

The Publicity Section, accordingly, began the preparation of a statement of the bureau's activities, and also made requests upon other sections of the bureau for data which could be thus issued.

Descriptive matter and photographs of ordnance material and achievements have been distributed to the press of the country, both directly and through the Navy News Bureau and the Navy Recruiting Bureau, and writers of special articles have also been furnished with material from which they have prepared their articles.

The Publicity Section has also cooperated with the leading motion-picture producers in securing the publication of films showing the work of the bureau. Naturally, a great amount of the motion-picture film in the bureau's files deals wholly with technical subjects, and, as such, is not well suited to popular distribution. There are many thousand feet, however, that are available for release, including a complete pictorial history of the organization of the country's industrial resources into manufacturing plants for the production of naval guns and mounts.

CHAPTER XVI.

THE INDUSTRIAL DIVISION OF THE BUREAU.

The activities of the Industrial Division of the bureau cover the following:

(*a*) The inspection of material manufactured for, procured by, or delivered to the Bureau of Ordnance, in accordance with standard or special plans and specification requirements as may be prescribed in the terms of the contract of procurement.

(*b*) The standardization of policies and methods of procedure in all matters related to inventions, patents, patent rights, royalties, infringements, interferences, claims, and kindred questions related to patent law requirements.

(*c*) Administration of all matters relating to the selective service regulations, in so far as relates to the personnel of the bureau, its field service and of private industrial plants engaged in ordnance work; the procurement of emergency fleet exemptions; and the return to essential industrial pursuits of men in active military service.

(*d*) Administration and standardization of policies and methods of procedure in all matters relating to labor; conditions of industrial employment; the application and adjustment of wage schedules and rates of compensation; investigation, arbitration, and settlement of labor disputes; and the coordination of labor questions in conjunction with other bureaus and departments of the Government.

For the purpose of executing the foregoing various activities of the industrial division, it was subdivided into the inspection section, the patent section, the selective service section, and the labor section.

On March 31, 1917, Commander A. L. Norton, United States Navy (ret.), was detailed as general inspector of ordnance, and directed to organize and build up the industrial division of the Bureau of Ordnance and direct all its activities.

THE INSPECTION SECTION.

The production of ordnance material prior to the war was confined to certain well-known industrial districts, which were located mostly east of the Allegheny Mountains, and at well-known shipbuilding yards on the Pacific coast, so that a limited number of officers under

the bureau were capable of supervising the production and inspection of material, assisted by civilian inspectors of ordnance material, who had been with the bureau for many years, and were familiar with the contract requirements for such material. The inspection service with these officers already under the bureau and with the civilian assistants, who had become familiar with the bureau's requirements, was capable of a rapid and effective expansion, so as to cover the activities of the bureau, which activities, immediately upon the outbreak of the war of 1917, rapidly moved westward and covered the greater portion of the region east of the Mississippi River.

The bureau was very fortunate in having at its disposal a number of retired officers who had previously spent many years in ordnance duty under it, and taking advantage of this opportunity, assigned them to inspection districts and to duties in the bureau, where their past experience and technical knowledge was utilized to the best advantage.

By arrangement with the Civil Service Commission, open examinations for civilian employees were instituted and new calls published for subinspectors, chemists, draftsmen, and laboratory assistants.

The area east of the Mississippi River was divided into inspection districts, as follows:

New England district.—Composed of Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, eastern New York, and northern New York, with headquarters at Bridgeport, Conn. Lieut. J. B. Staley, U. S. N., was placed in charge of the New England district.

New Jersey district.—Composed of southern and eastern New York, New Jersey and Delaware with headquarters at the works of the Crucible Steel Co., Harrison, N. J., Comdr. F. L. Sawyer, U. S. N. (ret.), was placed in charge of this district.

Bethlehem district.—Composed of northern Pennsylvania, east of the Allegheny Mountains with headquarters at the works of the Bethlehem Steel Co., South Bethlehem, Pa. Lieut. E. P. Finney, United States Navy, was placed in charge of this district.

Midvale district.—Composed of southern Pennsylvania, east of the Allegheny Mountains with headquarters at the works of the Midvale Steel Co., Nicetown, Pa. Commander A. C. Dieffenbach, United States Navy (ret.) was placed in charge of this district.

Maryland district.—Composed of the State of Maryland, with headquarters at the works of the Poole Engineering & Machine Co., Woodberry, Baltimore, Md. Lieut. Gilford Darst, United States Navy (ret.), was placed in charge of this district.

District of Columbia district.—Composed of the District of Columbia, Virginia, and West Virginia, with headquarters at the works of the Washington Steel & Ordnance Co., Giesboro Manor, D. C.

Lieut.-Commander E. H. Connor, United States Navy, was placed in charge of this district.

Southeastern district.—Composed of the States of North Carolina, South Carolina, Georgia, Tennessee, Mississippi, Alabama, and Florida, with headquarters at the Raleigh Iron Works, Raleigh, N. C. Lieut. J. J. London, United States Navy, was placed in charge of this district.

The Munhall district.—Composed of the States of Ohio, Kentucky, eastern Michigan, Canada, and Pennsylvania, west of the Alleghany Mountains, with headquarters at the works of the Carnegie Steel Co., Munhall, Pa. Lieut. Commander R. R. Adams was placed in charge of this district.

Chicago district.—Composed of the States of Indiana, Illinois, western Michigan, and all States bordering on the Mississippi River, with headquarters at Chicago, Ill. Commander Horace W. Jones, United States Navy (ret.), was placed in charge of this district.

The Pacific coast was divided into three inspection districts, as follows:

Northern Pacific district.—Composed of the States of Washington and Oregon, with headquarters at the works of the Seattle Construction & Dry Dock Co., Seattle, Wash. Commander W. W. Bush, United States Navy (ret.), was placed in charge of this district.

Central Pacific district.—Composed of northern and central California, with headquarters at the works of the Union Iron Works, San Francisco, Calif. Commander H. G. Leopold, United States Navy (ret.), was placed in charge of this district, and also of the southern Pacific.

Southern Pacific district.—Composed of the southern part of the State of California, with headquarters at the works of the California Shipbuilding Co., Long Beach, Calif.

Special inspection offices:

- Works of the E. W. Bliss Co., for torpedo construction.
- Works of the Sperry Gyroscope Co., for gyroscope instruments.
- Works of the Savage Arms Corporation, Utica. N. Y., for machine-gun construction.
- Works of the Ford Instrument Co., for fire-control instruments.
- Works of the New London Ship & Engine Co., Groton, Conn., for the installation of submarine-torpedo tubes.
- Works of the Lake Torpedo Boat Co., Bridgeport, Conn., for the installation of submarine-torpedo tubes.
- Works of the John H. Semple Co., Sewickley, Pa., for the production of detonating fuses.

Works of the New York Shipbuilding Co., Camden, N. J.
Works of the Cramps Shipyard, Philadelphia, Pa.
Works of the Bath Iron Works, Bath, Me.
Works of the Seattle Construction & Dry Dock Co., Seattle Wash.
Works of the Union Iron Works, San Francisco, Calif.
Works of the California Shipbuilding Co., Long Beach, Calif., for the installation of ordnance material in new ship construction.

The office of the Inspector of Powder, East Coast, with headquarters at Jersey City, N. J., maintained for the purpose of supervising the production of high explosives manufactured east of the Rocky Mountains, was enlarged materially.

With the cooperation of the Commandant of the Navy Yard, Washington, D. C., the Inspector of Ordnance in Charge of the Naval Torpedo Station at Newport, R. I., and the Civil Service Commission, the general inspector of ordnance was able gradually to obtain a large number of men who had had previous mechanical experience in the manufacture of ordnance material or similar material, and these were immediately appointed under civil service and assigned to the newly created districts as assistant inspectors of ordnance material.

In the early stages of the organization of the industrial division, the bureau was able to obtain, through the Office of Naval Militia Affairs, a few officers who had had more or less naval experience or technical training, and these were absorbed by the bureau and used as technical officers or assigned under the division to duty in the inspection districts. This source of supply of technical assistance, however, soon proved inadequate to meet the very rapidly growing demand for inspection and production personnel, so that permission was obtained from the Secretary of the Navy to enroll a limited number of college graduates as Reserve officers "for technical duties only," and in this wise was started the technical branch of the industrial division, which consisted of Reserve officers whose education and experience in civil pursuits fitted them for the highly technical duties demanded by the bureau. These officers, often experts in their special lines, were after short periods of instruction at the Washington Navy Yard, the Torpedo Station, or the Naval Proving Ground, assigned to the bureau or to the bureau's field inspection service.

The rapidly increasing volume of work in the field, the necessity for urging production, with the consequent increased demand for inspection, forced the bureau to expand this technical branch of its field service, and, as all regular officers, both active and retired were already fully employed, the Navy Department increased the

reau's complement of technical officers to approximately 300, all be used in the bureau or in its field service.

By a careful selection of personnel recommended by colleges and promotion of college-bred men already in the volunteer service of e Navy, the bureau was able to build up its technical division so to meet the full requirements of war production and the necessary spection of material.

It became apparent early in the war that a sufficient number of operly technically qualified civilians could not be obtained for the spection districts without injuring the bureau's other plants, from hich a large number of technically trained men had already been ken, and, the demand of industries engaged in production of war aterial having further reduced the supply of such personnel, the ireau was compelled to use enlisted personnel in its field inspection ork. Through the courtesy of the various commandants of the val districts both technical and administrative enlisted personnel ere obtained, so that on November 11, 1918, the field inspection rce consisted of about an equal number of civilian and enlisted rsonnel. These enlisted men were in most cases college graduates, ther mechanical, electrical, or constructive engineers, and gave most tisfactory service to the bureau.

THE NEW ENGLAND INSPECTION DISTRICT.

Prior to the outbreak of the war, the Bureau of Ordnance had a cal inspection office at the works of the American & British Manucturing Co., Bridgeport, Conn., having as a personnel one officer, ieut. J. B. Staley, United States Navy, in charge, and three civilian binspectors of ordnance. With this force as a nucleus the New ngland inspection district was organized. Through the courtesy of e American & British Manufacturing Co. the headquarters offices the district were maintained at those works, and steps were taken expand the district force to meet the production and inspection deands, the old organization taking on the load with no confusion. The character of inspection varied from gun mounts and guns, caridge cases, mining material and mines, depth-charge projectors, air mpressors, and variable-speed gears, in completed condition, to raw aterials of all kinds and much commercial material not technical in aracter.

At Bridgeport, it became necessary, because of failure to produce, 1 January 7, 1918, for the Army to commandeer the Liberty Ordance Co. a subsidiary of the Bridgeport Projectile Co. Lieut. ranklin Farrel, R. F., was placed in charge of Navy work here ntil the abandonment of the plant.

The Y gun for projection of depth charges from naval vessels v exclusively manufactured in this district at the works of the G eral Ordnance Co. This particular piece of ordnance was a n design and much outside of the usual run of ordnance materi being most successful in its operation in the war zone.

THE NEW JERSEY DISTRICT.

The New Jersey District was a distinct product of the war 1917. Prior to April, 1917, there were only a few scattered contra in the region now covered by that district, and these were supervis by an officer (Lieut. L. R. Leahy, United States Navy), with local fices at Brooklyn, N. Y. The first contracts of any considerable amou were placed with the Crucible Steel Co. of America, at Harris N. J., and there were then on duty, in addition to Lieut. Leahy, subinspectors of ordnance, engaged mostly on contracts for tanks the F. H. Lovell Co., and 5-inch shell bands at the Nassau Smelti & Refining Co. There were, in addition to these, 11 subcontrac The headquarters of the New Jersey District were established at t works of the Crucible Steel Co., and Commander F. L. Sawy United States Navy (ret.), ordered to take charge of the district April 7, 1917, and the work of building up the district inspecti force was begun. Lieut. W. V. N. Powelson, United States Na (ret.), reported on November 11, 1917, as assistant inspector of or nance, and served in this capacity until November 14, 1917, when l relieved Commander Sawyer as inspector of ordnance in charge the district, Lieut. Powelson being in turn relieved on January 1 1918, by Capt. A. A. Ackerman, United States Navy (ret.).

There were several interesting problems to be worked out i the district, one in particular being the difficulty experienced in ol taining sufficient power for the operation of the plants in centr New Jersey; the Public Service Corporation of this State was u able, on account of fuel shortage, to deliver the necessary and usu amount of power, with the result that, in many cases, plants we forced to shut down. In order to obviate this difficulty, represent tives of the Army, Navy, and Emergency Fleet met and perfecte an organization, so that, by submission to it of preferential orders it was possible to allot power in accordance with the relative im portance of the contract.

The material inspected in this district covered practically ever known ordnance device, together with raw, finished, semifinishe products, building material, navigational and scientific instruments.

There were several cost-plus plants in this district, the firm havin the largest contract being the American Radiator Co., Bayonne N. J., for 1,000 4-inch guns. There was a special manufacturin plant at the H. E. Boucher Manufacturing Co. for the manufactur

of mine gear, which was secret, and handled entirely by enlisted and commissioned personnel.

It became necessary to commandeer the Ordnance Engineering Corporation, which had been intrusted with the development and manufacture of star (illuminating) shell, owing to their not meeting the requirements of the contract satisfactorily. This plant at Baldwin, L. I., was taken over on November 23, 1918, by the Navy Department and operated by Lieut. Commander S. C. Mastick, R. F., under the direction of the Bureau of Ordnance.

Many matters of labor and wage questions arose in this congested district which were handled by this division of the Bureau of Ordnance through its labor section and its representative in the district. In this district, as in all other districts, there had been a number of cases in which the contractors seemed to have had no knowledge of, or, perhaps, respect for Government inspection and specifications. This naturally led to much complaint of the severity of inspection, but after a short time the complaints diminished as the contractors became more familiar with the obligations which they had taken on and as the organization of the inspection force was more fully developed.

THE BETHLEHEM INSPECTION DISTRICT.

The Bethlehem inspection district was, with the exception of the Midvale district, one of the smallest districts in area organized by the bureau. Previous to war activities, this office had been confined to the production of ordnance material at the works of the Bethlehem Steel Co. and the Ingersoll-Rand Co., Phillipsburg, N. J. The bureau simply expanded the already organized office at the works of the Bethlehem Steel Co., which at the outbreak of the war had one officer and five civilian subinspectors of ordnance.

The material inspected in this district consisted of guns, mounts, gun forgings, air compressors, shell, shell bands, shell forgings, and raw materials of all descriptions. One of the smallest districts in area and in organization, it stood fourth in the amount of material inspected and accepted.

Lieut. Commander E. P. Finney, United States Navy, was in charge of this district at the outbreak of the war and continued to administer this district until relieved, on December 4, 1918, by Lieut. Commander W. D. Greetham.

MIDVALE DISTRICT.

Previous to the outbreak of the war, the Midvale inspection district was confined to the Midvale Steel Co. and a few plants in the city of Philadelphia and vicinity. Naturally, many contracts were let at the outbreak of the war in this well-known industrial district.

Commander A. C. Dieffenbach, United States Navy (retired] officer of considerable ordnance experience, was ordered as inspe of ordnance, assuming duty on April 24, 1917, relieving Lieut. C mander H. E. Cook, United States Navy, who had been previo on duty as inspector of ordnance.

There was one cost-plus plan plant in this district, that of Tioga Steel Co., at which Lieut. Commander E. R. Mason, R. was detailed as the Bureau of Ordnance member of the compensa board.

The material inspected in this district consisted of armor, forgings, mine material, guns, gun mounts, armor piercing shell, various technical devices, together with raw material of all desc tions. The Bureau of Ordnance 7-inch tractor mount and 14-i railway mount projects were carried out in this district under direct supervision of the inspector of ordnance with a local o under Lieut. Commander D. C. Buell, R. F., who was in di charge of the project at the works of the Baldwin Locomotive C Eddystone, Pa. These two projects were carried to completion record time and resulted in five 14-inch railway gun mounts, gu and complete equipment train reaching the western front in time take an active part in the latter days of the war.

MARYLAND INSPECTION DISTRICT.

This district was a distinct outgrowth of war activities, as, p vious to the outbreak of the war there had been no contracts in t area. Lieut. Gilford Darst, United States Navy (retired) was order to take charge of this district, and an inspection force was bu up as rapidly as possible to handle the contracts which were bei placed in this area.

This office also represented the bureau in connection with the co struction and operation of the Poole Engineering & Machine Co. 4-inch gun plant that was built and operated on the cost-plus, fix profit basis, under contract No. 790. Work on this plant was begu on the 15th of October, 1917, and it was completed May 1, 191 Work was begun on the 4-inch guns May 15, 1918, the first gu being delivered January 29, 1919, with a total number of 60 gu delivered on July 1, 1919.

THE DISTRICT OF COLUMBIA DISTRICT.

In this district the principal contracts were with the Washingto Steel & Ordnance Co., of Giesboro Manor, D. C., Tredegar Co. Richmond Forging Corporation, Miller Manufacturing Co., Rich mond, Va., and the Grayson Tool & Manufacturing Co., Dunbar, Va. although there were many small contractors in the District of Colum bia, West Virginia, and Virginia.

At the beginning of the war, the principal material inspected was shell and shell material, but the war expansion was such as to embrace the inspection of submarine sights, spring compressors, shell extractors, bore sights, bomb-dropping mirrors, primer guides, subcaliber attachments, sheet steel, drop forgings, nonricochet projectiles, and woodwork.

THE SOUTHEASTERN INSPECTION DISTRICT.

The headquarters of this district were maintained at Raleigh, N. C., in the early stages of the war, but upon the completion of the contracts at the Raleigh Iron Works, the headquarters were shifted to the Birmingham Machine & Foundry Co., Birmingham, Ala.

Probably one of the most important war projects was the inspection of sylphons at the Fulton Co., Knoxville, Tenn., a part of the mining material used in the North Sea barrage.

MUNHALL INSPECTION DISTRICT.

Previous to this country's entering the war, the Munhall Inspection District was confined to the immediate vicinity of the city of Pittsburgh, Pa., with headquarters at the works of the Homestead Steel Works.

Quite naturally, many of the contracts let by this bureau at the outbreak of the war fell in this already well-established industrial region. At this time the district was in charge of Lieut. Commander R. R. Adams, United States Navy, assisted by five civilian subinspectors.

Upon the outbreak of the war, the district was expanded to cover western New York, western Pennsylvania, Ohio, Kentucky, eastern Michigan, and that portion of Canada lying east of Toronto.

The increased work due to new contracts after the declaration of war necessitated the establishment of suboffices in Cleveland, Dayton, Toledo, and Defiance, Ohio; Detroit, Mich.; and Sharon, Pa.; and required the stationing of commissioned officers at these suboffices.

The cost-plus plan of manufacture of ordnance was carried out at the Erie Forge & Steel Co., Erie, Pa.; Inland Ordnance Co., Bedford, Ohio; Defiance Machine Co., Defiance, Ohio; Recording & Computing Machines Co., Dayton, Ohio; Petroleum Iron Works Co., Sharon, Pa.; and the Olympian Motor Works, Pontiac, Mich.

The Alloy Steel Forging Co., due to financial conditions and inability to produce forgings, was commandeered by the Government on December 4, 1917, and the plant operated thereafter for the Navy Department by the Carnegie Steel Co. with marked success.

Two war projects carried out in this district were the manufacture of armor trains for the 7 and 14 inch railway mounts, trucks of which

were manufactured by the Standard Steel Car Co., and the p at the Carnegie Steel Co., and the manufacture of mine materi the Studebaker Corp., Maxwell Motor Car Co., and the Paige De Motor Car Co., Detroit, Mich.

Aerial bombs, depth charges, and mine spheres were manu tured in this district, all of which were different from the u class of manufacturing previously done. The 3-inch mount made at the Ohmer Fare Register Co., Dayton, Ohio.

A cost-plus contract was made with the Recording & Comput Machines Co., Dayton, Ohio, for the manufacture of broadside di tor firing instruments, and under this, instruments for 15 of first line battleships were manufactured, leaving but two sets to completed; these for the *Oklahoma* and the *Idaho*, upon the sign of the armistice. Manufacture of instruments will be continued this plant for the fitting out of the remaining vessels of the fleet

Many of the companies who had taken naval ordnance contra were assisted by the loan of experienced supervisors from the Uni States Naval Gun Factory, by the Bureau of Ordnance, who, w the services of the naval inspectors, enabled the companies to su cessfully manufacture and expedite the output of ordnance materi in most cases entirely new to the manufacturers.

THE CHICAGO DISTRICT.

Previous to April 6, 1917, the only personnel under the Bureau Ordnance in the area embraced by the Chicago district was Lie (j. g.) W. A. Lee, United States Navy, who was on duty at the pla of the Union Tool Co., West Chicago, Ill., engaged upon inspecti of some minor contracts at four Chicago plants. There were civilian inspectors nor enlisted personnel engaged in this area.

Almost immediately upon the declaration of war, contracts fo ordnance material were placed in the Middle West, so that th Chicago district became one of the most active districts under th bureau.

Commander Horace W. Jones, United States Navy, was ordere to take charge of this district, reporting for duty on June 7, 1917 Office space was obtained in the Edison Commonwealth Building

New plants on the "cost plus profit" plan were built at Madison Wis. (The Four Lakes Ordnance Co.), and at East Moline, Ill. (Th R. & V. Wagner Ordnance Co.), for the manufacture of 3, 4, and 5 inch guns and mounts, and large flat-price contracts placed with the Linderman Machine & Steel Co., of Muskegon, Mich.; the Goss Printing Press Co., the Miehle Printing Press Co., and the Allis-Chalmers Co., for gun mounts. Many minor contracts for ordnance material and subcontracts from firms located in other districts were taken over in this district.

NORTHERN PACIFIC INSPECTION DISTRICT.

The principal work under the Bureau of Ordnance in the Northern Pacific inspection district consisted of the installation of ordnance material on new construction and inspection of repair work at the navy yard, Seattle Construction & Dry Dock Co., Seattle, Wash., and the Todd Construction Co., Tacoma, Wash., with some powder inspection in Canada, at the works of the Hercules Powder Co., the inspection of which was carried on by this bureau's representative in charge of the naval ammunition depot at Ostrich Bay.

Commander W. W. Bush, United States Navy (ret.), was the Bureau of Ordnance representative in charge of the Northern Pacific district, acting also as the representative of the Bureau of Steam Engineering.

CENTRAL PACIFIC AND SOUTHERN PACIFIC INSPECTION DISTRICTS.

The principal work done by the Bureau of Ordnance in the Central Pacific district, which for the purpose of inspection was combined with the Southern Pacific district, consisted of the installation of ordnance material on new construction, repair of ordnance material, and the production of some smokeless powder by the Hercules Powder Co., which latter was inspected and supervised by this bureau's representative in charge of the naval ammunition depot, Mare Island, Calif.

Commander H. G. Leopold, United States Navy (ret.), was this bureau's representative as well as representative of the Bureau of Steam Engineering, with headquarters at the Union Iron Works, San Francisco, Calif., and also offices at the California Shipbuilding Co., at Long Beach, until the close of the latter plant.

OFFICE OF INSPECTOR OF ORDNANCE, E. W. BLISS CO.

The Bureau of Ordnance has always maintained an inspector of ordnance at the works of the E. W. Bliss Co. for the inspection and production of torpedo material, shell, and other ordnance material. The inspector of ordnance has supervision over the manufacture of the material at the works of the E. W. Bliss Co., and over the testing of all torpedoes at the Sag Harbor testing plant of that company.

During the period immediately prior to the declaration of war, there were pending at the works of the E. W. Bliss Co. torpedo contracts for approximately 1,016 torpedoes on contracts, all of which contracts were signed in 1915. On April 1, 1917, no torpedoes had been completed on any of these contracts, and, for some time previous, torpedo work had almost come to a standstill, due to the fact that the E. W. Bliss Co. had transferred most of its activities to work on shell contracts for the British Government. On April 1, there

were only 20 torpedoes approaching completion, although the material on hand in various stages of manufacture was sufficient to practically complete 500 torpedoes.

Immediately after the outbreak of the war of 1917, at the request of the Navy Department the E. W. Bliss Co. proceeded to close out its foreign shell contracts and to devote as much effort as possible to torpedo manufacture.

In addition to the torpedo contracts already pending, additional contracts were signed in 1917 and 1918 for additional torpedoes of various modern types.

The E. W. Bliss Co. expanded their manufacturing facilities by factory extensions that increased their floor space 40 per cent, and such extensions were devoted entirely to the manufacture of torpedoes under Navy contracts pending during the war. The cost of these extensions was about $2,000,000, which was financed by the Government and repaid by the company, including 4 per cent interest.

A new seven-story building was erected, with about 180,000 square feet floor space, and on November 11, 1918, was about 75 per cent tooled up for torpedo manufacture.

In addition to torpedo contracts on April 16, 1917, the Bliss Co. signed a contract for 10,800 6-inch common projectiles. Due to the shell-manufacturing facilities of this company resultant from their work on British contracts these shell contracts were completed in less than six months.

The work on torpedo contracts was expedited by the cooperation of the Government through the ordnance inspectors with the company. As a result, the torpedo output was increased from practically nothing at the outbreak of hostilities to about 150 a month at the end of the war.

The number of employees engaged in the manufacture of torpedoes at the E. W. Bliss Works when the armistice was signed was 3,145, as against approximately 600 employed normally previous to the war of 1917.

INSPECTOR OF ORDNANCE, SPERRY GYROSCOPE CO., INCLUDING THE WORKS OF THE FORD INSTRUMENT CO.

Previous to the outbreak of the war, the inspection of material for the Bureau of Ordnance at the Sperry Gyroscope Co., the Ford Instrument Co., and other companies doing work on fire-control apparatus was under the jurisdiction of the inspector of ordnance, E. W. Bliss Co., and this arrangement was continued until November 22, 1917, when Commander B. B. McCormick, United States Navy ret.), was detached from the E. W. Bliss Co. and ordered to take charge of the Sperry inspection office, with headquarters at the

Sperry Gyroscope Co., and with supervision over all fire-control instruments.

The bureau has always recognized the vital necessity of having the best fire-control system installed in vessels of the United States Navy, with an exact standardization and correlation of the various units. This is a difficult matter on account of the necessity of interconnection of the various instruments. The bureau, therefore, centralized the production of its fire-control instruments as much as possible in the two major plants of the United States capable of manufacturing instruments of this delicate character, and serious efforts were made to develop an independent supply of skilled labor and to establish a school for the training of selected men and women in the various branches of machine and instrument work. A school for the instruction of naval officers and enlisted personnel in fire-control instruments was maintained, with experienced instructors. Constant efforts were made toward the designing and development of new devices and toward the improvement of devices already adopted, so that the United States naval vessels might be equipped with fire-control instruments inferior to none, and, if possible, superior to any other naval power.

During the war, some 30 special devices for improvements on already installed devices were developed and perfected for use in fire control, all of which development, inspection, and manufacture was carried out under the supervision of the personnel in charge of this separate inspection office.

OFFICE OF INSPECTOR OF ORDNANCE, SAVAGE ARMS CORPORATION, UTICA, N. Y.

Immediately upon the declaration of war, the Bureau of Ordnance placed contracts to the full capacity of the Savage Arms Corp., Utica, N. Y., for Lewis machine guns and accessories.

This plant was made a special inspection office to which was assigned Lieut. H. G. Dohrman, N. N. V., later lieutenant commander R. F., and Chief Gunner T. C. Wester, U. S. N. (ret.), afterwards lieutenant (T), U. S. Navy.

The British Government had, previous to April 6, contracts with the Savage Arms Corp., and had at that time a large civil organization of inspectors. From this organization the bureau selected six of the most expert and best qualified inspectors and, by special arrangement with the British High Commission, was able to assimilate them into its organization. The inspection force, thus organized, was only one-fifth as large as the British inspection force, and it is noteworthy that several were female inspectors, who were especially adapted for the inspection of the many intricate parts of the Lewis machine guns.

Production at the Savage Arms plant was most satisfactory to this bureau, and Lewis machine guns were supplied not only to the Navy and Marine Corps, but also to the United States Army, which up to that time had no machine-gun contracts for this type of gun and were unable to place contracts in the United States.

The demands of the service were for standard Lewis machine guns and for aircraft machine guns. By mutual agreement between the War Department and the Navy Department, the production was supplied equally to the Army and to the Navy, in which latter were included the guns for the Marine Corps. There were 6,350 guns inspected for the Navy, 3,000 for the Marine Corps, and a like total number supplied to the War Department.

This arrangement continued until April 30, 1918, at which time, the Navy contracts being nearly completed, the office force, which had been organized and trained under Lieut. Dohrman and Chief Gunner Wester, was turned over to the jurisdiction of the United States Army to continue the inspection of the machine guns for that branch of the military service.

A machine-gun school was instituted at this plant, where marines and sailors with their officers were instructed in the construction, use, and handling of the Lewis machine gun.

After the inspection had been taken over by the United States Army at Utica, a running-in and testing station for aircraft Lewis machine guns was organized at the navy yard, Philadelphia, under the jurisdiction of the Bureau of Ordnance, where all material was run in, overhauled, and reinspected after delivery from Utica.

The taking over of a new type of machine gun, the quantity of production and the intimate and intricate inspection necessary was carried out successfully in face of many difficulties, notably the labor unrest at the works of the Savage Arms Co., which fortunately was never brought to the finality of a strike, due to the successful handling of the situation by the bureau's representative in charge of the inspection force.

INSPECTION OFFICE AT THE WORKS OF JOHN B. SEMPLE CO.

The inspection of detonators and fuses at the works of the John B. Semple Co. previous to the war of 1917 was conducted from the office of the inspector of ordnance at Munhall, Pa. The peculiarities of the material manufactured at these works require that inspection shall be carried on only by a regular commissioned naval officer. Previous to the war the John B. Semple Co. had but small contracts, working on their specially designed fuses and detonators. The demands of the war caused the company to enlarge their works, to build new works, and to increase their working force from about 50 at the outbreak of the war to 400 during the war.

The John B. Semple Co. has developed in fuse and detonator manufacture to a point that is a distinct asset to the Government. Mr. Semple has for years cooperated with the bureau in the development of fuses and detonators, and the firm was generally successful in meeting the bureau's requirements. New types of shell, antiaircraft, and antisubmarine detonators were devised and delivered under contract.

On April 1, 1917, John H. Rohrbacher, Commander, United States Navy (ret.), was ordered to take charge of the office of inspector of ordnance at the John B. Semple Co., and this office was made a separate inspection unit, and under this office was also placed the inspection of fuses manufactured at Fostoria, Ohio, at the works of the Fostoria Screw Products Co. This latter firm had had no previous experience in fuse work and experienced a great deal of difficulty in securing deliveries from subcontractors, and were sometimes late in the delivery of their contracts. One civilian subinspector was detailed to the office for duty at the Fostoria Screw Products Co., as the material manufactured by that company was not as delicate and hence not subject to the same restrictions as to inspection as was the material manufactured by the John B. Semple Co.

THE OFFICE OF THE INSPECTOR OF ORDNANCE, OPTICAL MATERIAL.

The principal sources of manufacture of optical instruments for the Bureau of Ordnance and other bureaus were the works of the Bausch & Lomb Optical Co., Rochester, N. Y.; and the works of the Keuffel & Esser Co., Hoboken, N. J. At the outbreak of the war the bureau had stationed at the works of the Bausch & Lomb Optical Co., Lieut. Charles H. Davis, United States Navy, as inspector of ordnance, optical material; Machinist Charles Swanberg, United States Navy, assistant inspector; with Chief Machinist F. J. M. Parduhn, United States Navy, as assistant inspector at the works of the Keuffel & Esser Co., Hoboken, N. J.

The peculiar character of the material entering into optical instruments, and the highly technical knowledge and experience required in the production of this material, had centralized the Navy's contracts in the firms mentioned.

Previous to the war, very little actual inspection of material of this type was carried on by the Government's representatives. During the war, owing to the speeding of manufacturing activities, it was necessary to go more fully into the detail of inspection of optical material, not only to guard against the errors coincident upon taking over new manufacturers, but also to assist these new manufacturers in the production of material.

The Crown Optical Co., of Rochester, N. Y., having failed in its obligations to the Government, was commandeered by the Navy Department December 15, 1917, and administered as the optical annex shop of the United States Naval Gun Factory, under Lieut. Commander L. C. Scheibla, United States Navy. This factory was administered until the close of the war, when most of its activities were transferred to the optical shop at the Washington Navy Yard.

Inspection work under this office included inspection for every bureau of the Navy Department. In addition to inspection work, officers and men were trained in the construction and care of optical instruments by short courses of instruction. During the war period there were 16 officers and 60 enlisted men under the direct cognizance of the inspector of optical material. This included the camera-repair class at the Eastman Kodak Co.

OFFICE OF INSPECTION OF POWDER, EAST COAST.

The original duties of the office of the inspector of powder, east coast, previous to the outbreak of the war were confined to the inspection of powder, both black and smokeless. Lieut. Commander Victor A. Kimberly, United States Navy, was in charge during the entire period of the war. As the war progressed, the inspection of high explosives (TNT, TNX, tetryl, and ammonium picrate), together with the loading of some of these materials in their final containers, was added to the duties of the office.

When new explosives and devices, whose functioning depended upon chemical reactions, were adopted, it became necessary to take up the inspection of additional raw materials and chemicals, and, due to the forms of some of the latter contracts, it became necessary to go into the inspection and analysis of acids in connection with the manufacture of high explosives.

Probably the most extensive project added to this office was the manufacture of TNX. When the Bureau of Ordnance adopted TNX as a high explosive to augment the supply of TNT, the output of the latter being insufficient to meet the demands of the war, it was necessary for the bureau to finance the building of an entire plant. Concurrent with this, in order to obtain the principal raw material, xylol, a special distilling plant was built, and solvent naphtha commandeered from all the coke ovens and illuminating gas companies throughout the country. The inspection and production of xylol was placed under the office of the inspector of powder.

Another extensive undertaking placed under this office was the supply of smoke-producing apparatus to be used in avoiding submarine attacks.

As this office consisted of highly trained technical personnel, this personnel was utilized in giving advice and assistance to small concerns, or concerns newly organized, engaged in the manufacture of explosives.

The activities of this office covered the United States and Canada, east of the Rocky Mountains, with plants as far west as Barksdale, Wis., and as far north as Belleoil, Canada, which entailed much travel on the part of the technical inspectors, inspection being made at some 50 different plants in the United States. The cost of inspection for the year 1918 was $82,502.58.

The duties of this office were particularly exacting owing to their highly technical character, the necessity for quantity production, and the widely separated geographical location of the various plants.

GENERAL.

Contracts for the year ending July 1, 1918, amounted to $479,-191,918.94, and, in addition, contracts were let during the fiscal year ending July 1, 1919, amounting to $57,078,173.80, making a total of $536,270,092.74. The pay of civilian personnel employed in the inspection of this material during the fiscal year ending July 1, 1919, amounted to $891,125.44, which was less than seventeen one-hundredths of 1 per cent of the total amount of the contracts. Many enlisted personnel were employed in the inspection districts, and the average pay of enlisted personnel so used amounted to less than nineteen one-hundredths of 1 per cent of the total amount of the contracts; omitting the cost of travel and office hire, the total cost of inspection was less than thirty-two one-hundredths of 1 per cent of the total amount of the contracts.

From another point of view, the inspection of material per pound in all the districts under the Bureau of Ordnance averaged less than 2 mills per pound, covering all classes of material; it must be considered that this is the average cost per pound, and that many of the bureau's more delicate instruments and high-class material required an inspection that ran at a cost per pound exceedingly high, so that the average cost per pound of material inspected during the war period is surprisingly low.

The bureau's inspection force visited, in the year 1918, more than 1,475 distinct plants where Bureau of Ordnance material was being manufactured and inspected, and accepted over 1,100,000,000 pounds of material.

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At no time during the war was production of ordnance material delayed on account of inspection or lack of inspection; and the bureau's representatives, with their assistants, maintained, throughout, the requirements for the delivery of material of high quality, in

full conformity with the specification and contract requirements. The bureau's representatives in the field force were able, by means of their technical education and experience, to aid, by their advice and assistance, contractors to whom the production of ordnance material was new. In addition, the bureau was able to furnish many contractors who desired it, men of long service and technical training at its Government plants, so that production was maintained at a maximum and material delivered was of the highest character. The bureau takes great pride in the fact that the full demands of the Navy were met at all times, and, in addition, much assistance rendered to the Army and other technical bureaus by its field inspection force.

THE SELECTIVE SERVICE SECTION.

Upon the passage of the selective-draft law it became necessary to institute a new section under the Industrial Division for the purpose of handling the Emergency Fleet classification lists as applicable to the Bureau of Ordnance employees in the field.

The purpose of the Emergency Fleet classification, according to the report of the Provost Marshal General (p. 64), was twofold:

> First, to defer and postpone the call for military service of the registrants placed thereon by reason of the fact that they were engaged in the building of ships, or the manufacture of fittings thereof under the supervision of the Navy Department or the United States Shipping Board Emergency Fleet Corporation, or were in training for or actually engaged in service as mariners under the general supervision of the recruiting service of the United States Shipping Board; second, to encourage men to engage in the building and manufacture of ships.

In so far as the Navy Department, and especially the Bureau of Ordnance, was concerned, the workings of the Emergency Fleet classification list was most satisfactory and effective.

Whether or not this arrangement encouraged men to engage in the building or manning of ships, the bureau has no means of judging; however, the report of the Provost Marshal General would indicate that the action of this list was most satisfactory and effective, causing many men to seek employment in the shipbuilding and allied industries, and this, without doubt, was of the greatest assistance to the Navy Department and the Emergency Fleet Corporation.

The bureau's experience, however, was confined to the effect of the Emergency Fleet classification list upon the civilian force at its various industrial plants, the Washington Navy Yard, the naval torpedo station at Newport, R. I., the naval ordnance proving grounds at Indian Head, Md., and Dahlgren, Va., at the various naval ammunition depots and stations, on its civilian force in the bureau, the inspection force in the field, and upon production at private industrial plants producing ordnance material.

The bureau's highly trained mechanical force at its various Government plants was amply protected by the retention of trained leading and key men, though the loss by voluntary enlistment and acceptances of draft calls was very large indeed; in many cases, such men were induced to forego the opportunity of reaching the military front line by arguments as to the value of their services in civilian pursuits.

By a special arrangement with the Provost Marshal General, the Chief of Bureau was given full authority to administer the Emergency Fleet classification list, where applicable to the bureau's yards and stations, bureau force, and field force, as well as to those private industrial firms having contracts under the bureau. This entire administration was centralized in the bureau under the general inspector of ordnance.

The exemption of essential men in private industrial plants was accomplished by the general inspector of ordnance through the inspectors of ordnance in charge of the various inspection districts and the local draft boards. *It is the bureau's opinion that, without the aid of the emergency fleet list exemptions, no contractor, except perhaps the very largest firms, could have completed their contracts anywhere near their contract time of delivery.*

While the regulations governing the use of this list were instituted primarily to force labor into the shipbuilding industry, it is apparent that the greatest benefit was accomplished, as far as this bureau was concerned, in retaining the leading or key men of the various bureau plants, and private plants working on bureau contracts, thus preserving the mechanical skill, knowledge, and experience that gave confidence and working ability to the organizations compelled to recruit the major part of their force from semiskilled or inexperienced labor.

It was soon demonstrated that men and women could be easily and quickly broken in to do some one particular line of work, such as lathe work, drill-press work or similar specialized work; but journeymen machinists, leading and key men on close work must be of long years of experience and training; such latter class of men were the ones retained under the emergency fleet list, sometimes against their desires, for the accomplishment of the industrial task imposed upon the bureau.

In all, this bureau placed under the exemption of the emergency fleet list, between 14,000 and 15,000 men; over 170 private industrial plants were thus protected.

During the war period, this bureau dealt directly with hundreds of local draft boards throughout the United States and met always with the heartiest cooperation in such dealings. It must always be

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borne in mind that more or less local influences were at work at all times upon the local draft boards in favor of or against men in their local districts, while, at the same time, these boards were called upon to furnish a stated number of men for entrainment by given dates, so that it was most necessary for the bureau and its representative to determine definitely that each exemption requested was for men actually engaged in the building of ships or the manufacture of fittings therefor. It is with pleasure that the bureau announces that in no case was any exemption requested by it refused by the local board to which such request was submitted.

In connection with the emergency fleet classification list, there was carried out a procedure of obtaining indefinite furlough for men already in the military service, in order to utilize their services in the more important work of producing munitions for the Navy. Applications were made by the bureau through the Secretary of the Navy to the proper officials of the War Department for mechanics of known experience and ability who were already inducted into the military service, and such men were then furloughed to the Bureau of Ordnance and returned to essential industries for the prosecution of the war. Only a limited number of men were obtained by this process, it being deemed more expeditious to make use of the emergency fleet classification list to retain men who were essential and necessary in the industries.

Ensign Frank O. Branch, United States Navy (ret.), afterward promoted to lieutenant commander (temporary), was placed in charge of the selective service section, reporting for duty on December 14, 1917. Lieut. Commander Branch was assisted by Lieut. (Junior Grade) C. B. Rugg, R. F., who reported January 4, 1918.

A very close and cordial relationship was maintained with the office of the Provost Marshal General of the Army and all activities of this section were conducted in such a manner as to conform to departmental requirements and policies, being guided always therein by the rulings and regulations issued by the United States Army.

THE PATENT SECTION.

Previous to the outbreak of the war in 1917, all matters involving questions of patent law were handled in the Bureau of Ordnance by Commander A. L. Norton, United States Navy (ret.), in conjunction with and through the office of the solicitor for the Navy Department. The increase in the number of questions involving patent law and other legal questions arising from war conditions rendered necessary the creation of the patent section in the Industrial Division.

Correlated with this section is a representative on the Army and Navy patent board who has cognizance of all matters relating to inventions before the Patent Office, with the view to determining what applications should be withheld from issue or publication as giving aid to the enemy; to locating inventions which might be of assistance in solving any problems in which the Bureau of Ordnance is particularly interested; to conferring with the departments and bureaus of both Army and Navy, as well as other Government institutions, on all patent questions for establishing uniformity of procedure and involving the general welfare of the entire service; to discussing and acting on pending legislation affecting patent questions; to conferring with foreign patent representatives regarding interchange of international patent rights.

Mr. Paul A. Blair, a practicing patent attorney of experience, was assigned by the office of the solicitor of the Navy Department to duty under the bureau in the industrial division and made chief of the patent section of that division, and later Ensigns R. M. Norris and T. C. Lindsay, R. F., were assigned as his assistants.

A close and cordial relationship was maintained with the office of the solicitor for the Navy Department and all matters of procedure and business of the patent section were conducted in such manner as to confer to departmental requirements and policies, being guided therein by the legal advice of and the legal opinions expressed by the solicitor.

The work of the patent section at first was devoted largely to the preparation of certain patent applications covering inventions originated and devised by officers of the Bureau of Ordnance, among the most interesting of which were perhaps those devices particularly adapted for combating submarines, such as depth charges, drifting mines, hydrostatic detonating mechanisms, nonricochet projectiles, etc.

Numerous questions of interest were also taken up in regard to validity and scope of certain patents, for the use of inventions covered by which large royalties were demanded. In some cases, the work of the patent section developed prior cases of public use or disclosure, rendering such patents invalid, thereby eliminating to a large extent any just claim for royalties for the use of such inventions.

In the fall of 1917, it was perceived that the Patent Office could probably furnish valuable information to both the Army and Navy by reason of the fact that many inventions on the latest types of munitions of all kinds were being filed each day. It was also perceived that the issuance and publication of patents covering these inventions might be of serious detriment to the country as advising

the enemy countries of the latest developments in war machines. For this reason, there was created the Army and Navy Patent Board, consisting of four officers and two civilians, representing the principal bureaus of both the Navy and War Departments. There was also appointed a legal adviser to this board, having charge of matters directly before the Patent Office.

The creation of this board and its work was dealt with at some length in a report furnished by that board and submitted to the Secretary of War and the Secretary of the Navy. It may be briefly stated that the primary object of the board was to furnish the various bureaus of both departments, through the representatives of each bureau, with such information regarding patent applications as were filed each week which might be of interest to those bureaus in the development of the particular line of work assigned thereto. Many inventions and novel ideas were suggested to the departments in this manner, which materially expedited the solution of certain war and munitions problems.

The second primary function of this board was to issue orders of secrecy against inventors from disclosing the subject matter of their inventions without special permission from the Federal Trade Commission and, also, to prevent the issuance of the patent applications on such inventions, thereby disclosing broadcast many important and valuable ideas.

The work of this board continued throughout the period of the war and for some time after the armistice was signed, when it was decided that its primary functions were no longer of material service to the country. The board, however, has continued in existence, and its primary function now is incidental to various investigations carried on by the different bureas regarding the validity and scope of certain patents upon which claims of infringement and demand for royalty are now being made.

Early in 1918, there was created a Munitions Patents Board consisting, primarily, of an officer of the Navy Department, an officer of the War Department, and Mr. Thomas Ewing, ex-Commissioner of Patents and a prominent practicing patent attorney in the city of New York.

This board has for its primary object the duty of passing upon the question relating to payments of royalties on inventions used by both the Army and Navy, thereby to establish, as much as possible, a uniformity of practice on the disposition of matters of that character.

Mr. Blair, who had been elected chairman of the Army and Navy patent board, was also appointed liaison officer acting between the Bureau of Ordnance and the munitions patent board through the office of the solicitor.

The Patent Section of the bureau has, during its existence, filed in the neighborhood of 70 applications for patents on various devices, such as mines, torpedoes, explosive compounds, projectiles, and accessories thereto. It has also conducted several interferences, where conflict on inventions made by officers of the department occurred with the inventions developed by parties not connected with the service. It has taken an active part, with the aid of the solicitor, in the formulation of numerous contracts regarding royalty payments, as well as having made numerous investigations on the validity and scope of the patents and the patentability of ideas and inventions upon which royalties might be made, with the result of locating data which, in the opinion of the Patent Section and the solicitor, invalidated such patents and nullified any well-founded claim for compensation. The officers of this section have also been actively associated with numerous special boards, appointed by the chief of the bureau, of officers of the bureau, in determining various questions involving patent rights.

THE LABOR SECTION.

From the experience of the bureau with labor unrest in the early months of the war, it was deemed advisable to create an additional section in the industrial division in order to take care of the many labor problems arising in connection with the inspection and production of war material. This section was created early in 1918, and it was the province of this section to keep in touch with all manufacturing plants and all industrial centers, where the Bureau of Ordnance had material being manufactured; later the activities of this section were extended to cover all labor conditions for the Navy Department, and the general inspector, in charge of the industrial division, acted as liaison officer between the War Labor Policy Board, the War Labor Board, and the various other organizations dealing with labor conditions.

The bureau enrolled a number of officers of mature age with more or less legal experience for duty in this section, with the general inspector of ordnance, Commander Norton, as head; this section immediately took the necessary steps to become familiar with all housing, transportation, sanitary, and welfare conditions, including living costs, amusements, rentals, and all other conditions affecting labor surrounding the industrial plants working for the bureau. Officers were assigned to duty in the New England, Munhall, Midvale, New Jersey, Bethlehem, Chicago, and the District of Columbia district, became acquainted as far as possible, not only with the conditions enumerated above, but with the mental condition of labor, the

relation of management and employer to labor, and collected, tabulated and filed for reference the general conditions surrounding industrial plants. By means of this organization, the bureau was able to keep in touch with all conditions at its industrial plants, and at private plants doing work for it, and was often able to forecast unrest or, when discovering the same, prevent its growth or spread by careful remedying of conditions or the adjustment of differences between employer and employee.

The bureau's representatives in no way acted as conciliators or mediators, but rather as means of communication by which an impartial review of the situations arising might be laid before the employer and employee, and thus cause to be remedied unfavorable conditions, such as transportation, housing, amusements, living costs, etc., or cause to be removed impressions or conditions tending to cause or increase the spread of labor unrest. *It is a noteworthy fact that at no industrial plant, where Navy ordnance material was being manufactured, did any strike or walkout last more than 48 hours, and in many cases walkouts were prevented, or the men returned to work almost immediately after walkouts, by the bureau's representatives after a thorough investigation of conditions, and mutual understanding was established between the contending parties.*

The general inspector's industrial staff consisted of Lieut. Commander S. C. Mastick, R. F., Lieut. H. G. Dohrman, R. F., Lieut. J. F. Easterbrook, R. F., Lieut. G. H. Johnson, R. F., and Lieut. E. L. Tinker, R. F., operating directly under the general inspector and coordinating with the office of the Assistant Secretary of the Navy; in addition to these, there were other commissioned officers in the field service actively engaged in keeping in touch with industrial conditions.

Ensign B. B. Weiss, afterwards Lieut (j. g.), R. F., was detailed as liaison officer between the office of the Secretary of the Navy, the War Department, and the office of the general inspector of ordnance, and by this means was able to cooperate with the War and Navy Departments in connection with all industrial situations. By such cooperation, it was possible to maintain production of war material by insuring cordial relations and cooperation between employer and employee and, what is more important, furnish an unprejudiced means for communication and cooperation between the departments, organized labor, unorganized labor, and employers of labor.

The labor section was only well under way upon the signing of the armistice, but from the excellent results obtained during its short period of existence, it is believed that in a few more months its influence would have been much more strongly felt. As specific instances of the effectiveness of this organization, there is mentioned the ad-

justment of difficulties at the works of the Mead-Morrison Manufacturing Co., Boston, Mass., whereby a general walkout was prevented, so that production of gun mounts, so necessary for the manning of the main and auxiliary vessels of the Navy, was not delayed; a general strike at the works of the E. W. Bliss Co., New York City, which lasted but a few hours, was immediately adjusted and the men returned to work so that the production of torpedoes and torpedo material was continued at the full capacity of these works. Labor difficulties at Hagerstown were adjusted, as well as in smaller towns in the surrounding country; the control of labor unrest in the Pittsburgh district, and especially the handling of the Pittsburgh railway labor situation in the fall of 1918 was most important; the maintenance of production in the Chicago district; the adjustment of difficulties at Waterbury and at Danbury, Conn., and the handling of the labor situation at Bridgeport, Conn., were all of far-reaching results. There was much excellent work done by this section's representatives in the New Jersey district, in preventing several threatened walkouts and in clarifying situations which would otherwise have resulted in the slowing up or possible stoppage of production; the adjustment of difficulties at the Defiance Manufacturing Co., Philadelphia, Pa., at the York Manufacturing Co., York, Pa., and other minor threatened labor disturbances and unrest in the immediate vicinity of Philadelphia are worthy of mention as having been accomplished most successfully by this bureau.

Perhaps the action of this section most worthy of mention was the adjustment of labor difficulties incident to the construction of the extension to this bureau's industrial plants for the manufacture of powder at Indian Head. This being a plant situated far from industrial centers and at considerable distance from any city or even village of any size, conditions were most unfavorable for the employment of labor or for maintaining the contentment of labor after employed. Much friction soon developed between the contractors and their employees, and the services of the labor section were often called upon to maintain construction at its required rate of progress. From the experience gained in adjusting difficulties at this place, the Bureau of Ordnance recommended a policy to the Navy Department, as follows:

(1) Eight hours to constitute a day's work.
(2) Time and a half to be paid for all overtime work.
(3) Double time to be paid for Sunday work.
(4) Forty-eight hours to constitute a week's work.
(5) No overtime to be paid to any employee who had not worked more than 40 hours during the week for which overtime was claimed.

The Navy Department approved this policy and promulgated it as the Navy Department's policy, and it was immediately instituted in all of the Bureau of Ordnance industrial plants and at the plants of firms doing work for the bureau. The bureau takes pride in the fact that this policy, determined upon from its experience, became the policy of the War Labor Board, and was promulgated by that board as such at a later date.

The effectiveness of the bureau's policy in keeping informed of all labor conditions and keeping in touch with the mental aspect of labor, was manifested in continued production of ordnance material provided by this bureau at the highest rate of speed.

NAVY ORDNANCE FLAG

Approved by the Secretary of the Navy October 18, 1918, and authorized to be flown over Bureau of Ordnance industrial plants and stations and over such private industrial plants as are devoting at least 50 per cent of their capacity to Navy Ordnance work.

245-1

NA [illegible]

[illegible]

[illegible] of ordnance [illegible]

[illegible] Bureau.

[illegible] stations [illegible]

[illegible]

war.

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CHAPTER XVII.

NAVAL ORDNANCE STATIONS.

The Bureau of Ordnance exists as an administrative unit of the Navy Department. Its duties, as has been outlined earlier, are to supply ordnance equipment to the fleet. It might well purchase guns, ammunition, and other materials by contract and ship these direct to the vessels to which assigned, provided only the ordnance materials were as standardized and as common as furniture and chinaware.

But naval ordnance equipment is of a class to itself. Its manufacture can in large degree be carried out by private contractors, but only under rigid specification and inspections. The assembly and test of all material, however, and, in fact, even the manufacture of certain items, must be carried out under more direct control of the bureau than that of inspectors at a private plant. Naval officers and naval crews must use this material aboard ship; the responsibility for its satisfactory action or its failure lies upon the bureau. An accident causing great loss of life, an inefficiency of material leading to the loss of an opportunity to inflict severe damage upon the enemy, may result from failure of even the smallest part of ordnance equipment.

To best insure the quality of the ordnance materials issued to the service, the bureau therefore maintains under its own direction a number of naval ordnance stations ashore, commanded by seagoing naval officers of ordnance experience, and operated under direct orders from the bureau.

To each of these shore stations falls one or more of the duties of manufacture, assembly, overhaul, and test of ordnance equipment.

These stations comprise the gun factory, proving grounds, powder factory, torpedo stations, mine depots, armor plant, ammunition depots, and the several commercial plants for the manufacture of ordnance gear taken over and operated by the bureau during the war.

The work of the ammunition depots in assembling and overhauling ammuniton for issue to the naval and armed mercantile fleet has been described in the chapter on ammunition. Similarly, the operation of the several plants taken over has been noted under the chapters descriptive of the material which those plants turned out.

The Naval Gun Factory at Washington, D. C., was early established to supply the naval service with guns. By many expansions this plant has kept abreast of the peace-time needs of the Navy. In war, naturally a vast amount of guns was procured from outside firms, but that these firms were able to perform the work is due largely to the information and cooperation furnished them by the gun factory.

All ordnance material must necessarily be tested, and the only test for a gun, a projectile, or a powder, which is really worth while is actually to fire it. Every gun the Navy uses is first fired to test its strength; a sample of every powder index and of every lot of projectiles is fired to insure proper action. For 30 years the bureau has maintained a testing or proving ground at Indian Head, Md. During the war, an additional proving ground at Dahlgren, Va., was developed in order to obtain the long range required for testing modern, high-powered guns.

Like its guns, the Navy manufactures in large part its own powder. This is done at the Naval Powder Factory, an adjunct of the proving ground at Indian Head.

Perhaps the most complicated and delicate weapon of naval ordnance is the torpedo. The bureau maintains the Naval Torpedo Station, Newport, for the manufacture, test, and overhaul of torpedoes, the Naval Torpedo Station, Keyport, Wash., for the overhaul of torpedoes belonging to vessels on the Pacific coast, and, during the war, inaugurated the torpedo assembly plant at Alexandria, Va., for the production in quantity of torpedoes. The Naval Gun Factory at Washington, D. C., also has recently taken up the manufacture of torpedoes.

Prior to the war, comparatively little was done in mining in the United States Navy, and such ordnance material work as was concerned therewith was carried on by manufacture at the Navy Yard, Norfolk, and by assembly and issue at the several naval ammunition depots. With the enormous advance in mining during the war, however, the bureau, although manufacturing its mines by outside contract, provided a large mine depot at Yorktown, Va., and a smaller one at New London, Conn.

Some time prior to the war Congress had authorized the construction of a naval armor plant and made appropriations therefor. At the beginning of the war, the construction of this plant had been commenced at South Charleston, W. Va. As the war progressed, it became apparent that little armor would be needed but that guns were a constant necessity. Accordingly, provision was made for the manufacture of gun forgings at the armor plant, and in view of this additional character of work, it is now known as the Naval Ordnance Plant, rather than the Armor Plant.

During the war, practically all the ordnance shore stations were actually enlarged both in land and in buildings. Additional and extensive building operations became necessary, and an officer was detailed to act in a liaison capacity between the Bureau of Ordnance and the Bureau of Yards and Docks in regard to public works and ordnance.

The volume of work increased so rapidly that on July 1, 1918, a Buildings and Grounds Section was formed to have cognizance over the layout, development, arrangement, and construction of all buildings and grounds at ammunition and storage depots; manufacturing, assembling, loading, and industrial plants; housing; railroad connections and equipment; roads, wharves, slips, piers, and water, light, sewerage, and communication systems under the cognizance and control of the bureau. Lieut. Commander W. W. Little, R. F., was in charge of the section, which later expanded to a personnel of 12.

Consideration of follow-up and financial questions, in consultation with sections concerned, of all matters relating to plant requirements at naval ordnance stations, ammunition depots, magazines, mine-loading and storage depots, torpedo stations, gun factory, and proving ground, required the examination of all plans and proposals submitted by the Bureau of Yards and Docks in connection with the layout and construction of all buildings, grounds, and public utilities of those stations and of other ordnance industrial plants.

New projects were started as the necessity therefor arose; notably the new proving ground at Dahlgren, Va., the Navy mine depot at Yorktown, Va., torpedo assembly plant at Alexandria, Va., and storage buildings for ordnance material at Bellevue, D. C. The total amount of land taken for all improvements amounted to approximately 14,873 acres, of which about 14,174 acres were for the mine depot at Yorktown, Va., and the proving ground at Indian Head, Md., and Dahlgren, Va. Storage facilities at all depots and stations were increased by approximately 2,000,000 square feet of covered area over prewar conditions.

Detailed notes follow of the operations of the naval ordnance shore stations during the war.

THE NAVAL GUN FACTORY.

To the Naval Gun Factory belongs the distinction of being the oldest, and at the same time the most important, manufacturing plant under the Bureau of Ordnance. Established early in the last century in Washington, D. C., it has been the main source of supply of guns and their appurtenances to the Naval Service. From the days of the old muzzle-loading smoothbores—the 18, 30, and 60 pounders of the frigates and ships of the line—to the advent of the first rifled Dahlgrens in Civil War times; then on to the present

day, with its great floating batteries of 14-inch rifles capable of sinking an enemy at a range of 20,000 yards, the Naval Gun Factory has been fully abreast of every advance in gun construction and has kept our Navy equipped with ordnance unexcelled by any afloat.

At the beginning of the war, the gun factory was supplying the greater part of the guns needed for such vessels as were from time to time added to the regular Navy, and also replacements for the guns worn out in service. The guns were received as rough forged cylinders of various diameters, from which the finished gun, of concentric elements shrunk together, was machined, assembled, and completed. In addition, a great deal of ordnance material of other kinds was fabricated there, such as gun mounts of all kinds, sights and sight equipment, spare parts and accessories for guns and mounts, turret ammunition hoists, cartridge cases and fuses, torpedoes and torpedo tubes.

Special mention should also be made of the drafting room of the Naval Gun Factory. Unlike the ordinary drafting room that every manufacturing plant maintains in connection with its works, this particular one was established with the primary object of being the main design section of the Bureau of Ordnance. It comprised a number of highly skilled ordnance engineers and designers, whose ability and experience enabled the bureau to accomplish successfully some of its biggest tasks during the war.

At the outbreak of war the gun factory, already working to full capacity in some of its shops, was pressed to the maximum in all its activities. Throughout the entire war period work was continued at full blast and a great amount of most valuable ordnance material for the Navy was produced. In addition, the expansion of the gun factory was carried out with greatest expedition, and before the armistice a number of important new branches were in operation.

The most important work and improvements of the gun factory may be summarized as follows:

(*a*) More than 300 guns were manufactured, many more were partially manufactured, and others were relined and rebuilt. These guns varied in size from the 16-inch 50-caliber to the small 3-inch boat gun and the 1-pounder. Nearly 3,000 guns furnished by outside contractors were star-gauged, examined, and put in condition for service.

(*b*) Breech mechanisms were manufactured for all the guns made at the gun factory as noted above, a large number of spare breech mechanisms were made and many others were overhauled, modified, repaired, and spare parts manufactured to supply the needs of the service.

(*c*) Some 500 gun mounts, also ranging from 16-inch to 1-pounder, were manufactured. Over 3,000 mounts as manufactured by outside

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VIEW OF 14-INCH 50-CALIBER GUN ON GIRDER IN GUN SHOP, NAVAL GUN FACTORY, WASHINGTON, D. C.

mand in the battle fleet at sea. The assistant superintendent, Capt. A. L. Willard, succeeded to the superintendency and carried the gun factory along to April 30, 1919, when the present superintendent, Rear Admiral A. W. Grant, U. S. Navy, assumed charge. Capt. M. E. Trench was assistant superintendent from October, 1917, to September 12, 1918, when he assumed command of the torpedo station at Newport, being relieved by Capt. D. E. Theleen. In September, 1917, Commander W. W. Smyth was relieved by Commander Harvey Delano in charge of the design and drafting work for the Navy's ordnance matériel.

Without the gun factory the bureau would not have been able to arm the vessels of the merchant marine. The demand for guns, mounts, accessories, and spare parts for ordnance material exceeded all expectation, and it was only by the experience and the ability of the gun factory that such material was manufactured; in addition, the guidance by the gun factory of the manufacturing plants of the country newly undertaking naval ordnance work, proved the salvation of those plants in the early and accurate production of their work. Trained supervisory force was obtainable from no other source.

NAVAL PROVING GROUNDS.

A.—INDIAN HEAD, MD.

The Bureau of Ordnance has long maintained a proving ground at Indian Head, Md., on the shore of the Potomac River, some 22 miles below Washington. At that proving ground it has tested every gun bought for the Navy, as well as specimen samples of every lot of powder, shell, fuses, and cartridge cases. In addition, armor-piercing shell and armor are tested by firing the one against the other.

The increase of proof work from prewar basis to the rush of war-time tests is shown by the comparative figures of the period immediately preceding the war and that subsequent to the inception of war contracts. The following tables give these comparisons:

	Fiscal year.		
	1916-17	1917-18	1918-19
Guns:			
Major caliber	45	33	44
Intermediate	299	851	3,063
Minor caliber	150	235	344
	494	1,119	3,451
Smokeless powder ... pounds..	337,779	558,168	831,033
lots..	212	263	522
Primers ... lots..	1,500	1,789	1,970
Cartridge cases ... lots..	346	...	1,271

THREE 14-INCH 45-CALIBER GUNS ON ONE SLIDE AS MOUNTED ON ARIZONA AND PENNSYLVANIA. READY FOR TEST AT PROVING GROUND.

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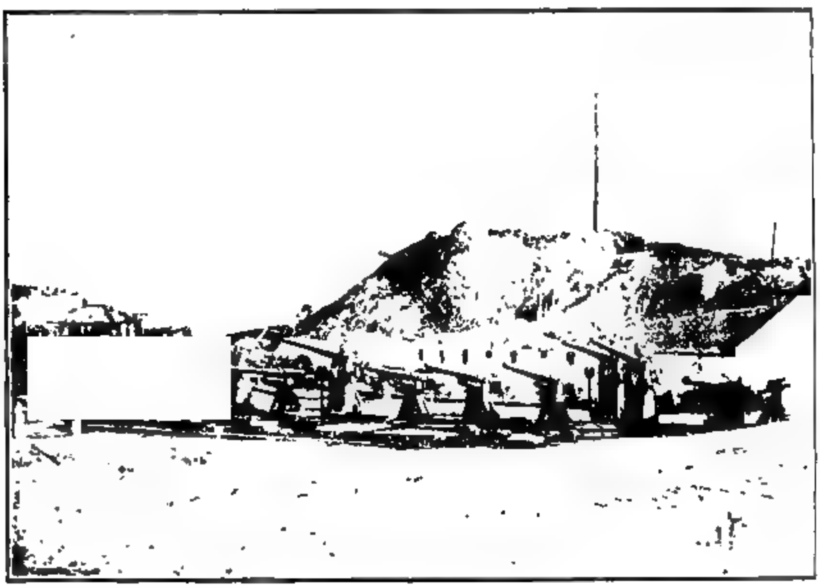
RANGING BATTERY IN THE VALLEY AT PROVING GROUND, INDIAN HEAD, SHOWING GUNS OF LARGE CALIBER, OBSERVATION PLATFORMS, AND, AT THE RIGHT A GANTRY USED FOR TRANSPORTING GUNS.



SMALL-CALIBER GUNS IN THE WEST BATTERY AT PROVING GROUND, INDIAN HEAD, MD.

The obstacles to the accomplishment of such increases in the tests were not alone those of pure quantity of material to be tested. Space was the prime and most serious difficulty.

It is not possible to move a proving ground within a short limit of time. The great amount of structural work that goes with gun mounting, and plate or projectile testing, entails a long period of preliminary construction. It was deemed impossible, therefore, at the beginning of the war to entertain any idea of immediate transfer of proof activities to another site. The proving ground itself—that is, the area on which ordnance material may be tested, is in the shape of an isosceles triangle, roughly 800 by 400 feet. This is termed the "valley." Topographical advantages of high surrounding land, well wooded, made it possible to carry out a portion of the desired tests, but even these endangered surrounding buildings and inhabitants. But these very advantages of the ground made lineal expansion practically impossible.

The problem then was to increase the battery dimensions without permitting firing beyond the limits of the valley proper. This was done in two ways: First, the number of batteries was increased to four, firing in two general directions, up and down the river, and overlapping one another. By their relative situation these batteries were named the North, South, East, and West batteries. Special shelters had to be built, new and extraordinarily stringent rules had to be put in force, and an intricate system of transportation had to be devised. Within a few weeks after the declaration of war, practically an entirely new lot of batteries was in commission, and the proving ground was handling as many barges, loaded with guns, as there had been guns themselves previous to the war.

In order to provide storage space for the great quantities of material arriving for test, new magazines had to be built, and new platforms for shells, new areas cleared for parking guns, and new housing for perishable material of every sort. The great mass of this construction work was done by the valley force itself by snatching moments between the various performances of routine proof.

It was found that many items of equipment that were satisfactory in peace time could not carry the strain of war speed. An example of this was the type of butts in use. Prior to the war, a few plate or shell tests a month permitted easy renewal of butt forms. When tests multiplied to several in a single day, it became necessary to contrive a butt structure that would withstand attacks over a long period without serious repair other than simple blocks and wedges. The proving ground succeeded in producing a butt which was nearly permanent and eminently satisfactory.

As continual proof work in the daytime gave little opportunity for transfer of guns, projectiles, and the other materials it was neces-

sary to work in shifts. In this way the actual proving-ground work rarely ceased entirely throughout the 24 hours. Officer personnel attached to the station at the beginning of the war was in no way adequate to the situation. To fill vacancies and create leaders for each branch of proof work a number of Reserve officers of the technical class were broken in by a short course of specialized instruction. Thereafter, the bulk of proof work was done by either reserve or temporary officers under the direction of a handful of regular officers.

The advent of the war developed such an increase in experimental ordnance that on June 30, 1917, this work was placed under one officer under whom various assistants were appointed from time to time as the work demanded more personnel. Owing to the increase in routine proof work, the actual conduct of experiments was at all times difficult because of lack of adequate facilities.

The work done on experimental ordnance during the war covers such a wide field that the subjects can be mentioned only in a general way. The following subjects were investigated, some completely and others along some particular line:

Guns: Machine, howitzers, aero, twin mounts, Davis.

Shell: Asphyxiating, high capacity, 16-inch A. P., line carrying, nonricochet, smoke; test on premature bursting of.

Explosives: Tetryl, TNT, mines, guncotton, various shell fillers, explosive D.

Fuses: A large number of experimental fuses of various manufacture were tested.

Miscellaneous: Aerial bombs, directorscope, caissons, incendiary bombs, subaqueous pressures, primers, erosion, tracers, gas-masks, inclined impacts, experimental armor, detonation tests, gas ejector, type powders, ammunition stowage, tests of service material under certain war conditions.

During the war the proving ground was commanded by Capt. H. E. Lackey, U. S. N., assisted by Commander C. W. Mauldin, U. S. N., as second in command; Lieut. Commander C. L. Lothrop, U. S. N., as proof officer, and Lieut. Commander A. G. Kirk, U. S. N., as experimental officer.

B.—DAHLGREN, VA.

For some years prior to the war, the bureau had realized that the naval proving ground at Indian Head was inadequate to care for the increasing proving work, first because its area was limited, and second because the straightaway water range down the river was too short for the testing of modern guns. Appropriations were lacking, however, to secure another proving ground, and it was not until the war that the bureau was able to purchase some 1,366 acres of land at Machodoc Creek, Va., an additional 97 acres was acquired by the

THE "VALLEY" AT INDIAN HEAD, SHOWING UPPER END OF NORTH BATTERY IN THE FOREGROUND AND ARMOR AND SHELL TESTING BUTTS IN THE BACKGROUND ON THE RIGHT.

The congestion along the railroad tracks at the left made difficulties for the transportation force.

MEDIUM CALIBER BATTERY, LOWER PROVING GROUND, DAHLGREN, VA.

FUSE-TESTING BATTERY, LOWER PROVING GROUND, DAHLGREN, VA.

NITRATING PLANT, POWDER FACTORY, INDIAN HEAD, MD. BLENDING TOWER MAY BE SEEN IN THE UPPER RIGHT-HAND CORNER.

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POWER PLANT FOR THE VARIOUS UNITS OF THE POWDER FACTORY INDIAN HEAD, MD

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ETHER HOUSE, SHOWING DRYING HOUSES IN THE BACKGROUND, POWDER FACTORY, INDIAN HEAD, MD.

252-5

WEAK ACID MIXING BOXES, PREHEATER HOUSE, FILLER, AND BLOWER HOUSE, POWDER FACTORY, INDIAN HEAD, MD

purchase of Blackistone Island, and to begin thereon the construction of a great and complete proving ground. A complete battery of guns of all sizes, firing down a clear water range of nearly 90,000 yards, was planned, in addition to extensive armor butts and fuse batteries, and the necessary quarters and administration buildings.

This proving ground was assigned under the command of Capt. Lackey, and directly under the charge of Lieut. Commander S. A. Clement, U. S. N.

Construction was started on May 28, 1918, and before the end of the war a fuse battery had been set up and the pressure of work at Indian Head in that line had been materially relieved. Since the war the construction of the station has continued, and when completed this proving ground will enable the bureau really to progress in all ordnance lines.

POWDER FACTORY.

With the adoption of smokeless powder for our Navy in 1899 there arose the question of facilities for its manufacture. The Du Pont Co., at Carney's Point, Haskell, and Parlin, N. J., were the main manufacturers, there being also a very small Navy experimental plant at Newport, R. I. The Navy Department established its own powder factory at Indian Head, adjoining the naval proving ground, with the prime object of decreasing the cost of powder, increasing its stability and bettering its quality. This factory was increased from time to time until at the outbreak of the war it was able to turn out 20,000 pounds of powder per day. This rate had been sufficient to keep the Navy supplied with target-practice ammunition and with about one-half of the powder required for service outfits for the Navy, the remainder being bought by contracts.

With the enormous expansion of powder needs during the war, the Navy placed outside contracts and also undertook greatly to enlarge the capacity of Indian Head.

The expansion plan adopted provided for a capacity of 60,000 pounds per day of air-dried powder, with an increase to 80,000 pounds or 100,000 pounds when the additional amount was dried by the water process. E. I. du Pont de Nemours Co. planned and erected the required sulphuric and nitric acid plants, accomplishing this work in ample time despite unusual difficulties. The factory was less fortunate in all its other projects under the expansion plan, and they were still uncompleted at the close of hostilities.

In addition to its normal functions, the powder factory was called on to furnish additional technical force for inspection duty in connection with purchase of explosives; and the laboratory was practically a training school for these men. The laboratory was also called upon to make final inspection of all outside purchases of

explosives, involving an increase of 400 per cent in powder work and 600 per cent in explosive work.

A quantity of nitrate of soda ordered for the station was diverted to allied countries and, as the war went on and it became more and more difficult to secure nitrate from Chile, it became extremely desirable to build a nitrogen fixation plant to meet the needs of the Navy. Indian Head was chosen as the site for the plant to supply this station, and work on this plant had just started when the armistice was signed and the contract was canceled.

During the war, as for many years before, the powder factory was superintended by Powder Expert G. W. Patterson, acting under the inspector of ordnance in charge of the proving grounds.

NAVAL TORPEDO STATIONS.

A—NEWPORT, R. I.

The naval torpedo station at Newport, R. I., was the first establishment of this character built in the United States. It has long been the Navy's primary station for torpedo design, development, and experimental work. At it all torpedoes are proved and torpedo outfits assembled before issue. In addition to torpedo work, mine, primer, and fuse experimental work and manufacture is carried on. A large torpedo factory is operated in conjunction with the other facilities. The torpedo schools, for training of both officers and men, are located at and operated by the torpedo station, Newport.

The war threw an extraordinary increased burden upon the torpedo station, principally as regards the assembly and issue of material.

The following summary of activities for the fiscal years 1917, 1918, and 1919 is given as representative of the increase in activities and importance of this station during and immediately after the war:

	Fiscal year.		
	1917	1918	1919
Torpedoes manufactured	237	248	302
Torpedoes received	186	512	1,169
Torpedoes issued	552	388	1,735
Torpedoes repaired	330	533	508
Shots fired on range	1,674	2,130	997

In addition to the above, manufacture of torpedo air plant, separators, and mines; loading of war heads, mines, and depth charges; manufacture of primers, fuses, spare parts, and mechanisms was carried on.

Experimental work of a highly valuable and confidential nature was done. It was here that the design for the American depth

INDUSTRIAL PORTION OF U. S. NAVAL TORPEDO STATION, NEWPORT, R. I.

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charge was made and the test of these depth charges carried out. Earlier tests in the development of the Mk. VI mine, as used in the Northern Barrage, were made. A number of other experiments with torpedoes, mines, and depth charges were carried out, and this station may be considered the primary testing station for *underwater* weapons, as opposed to the naval proving grounds where *ballistic* weapons are tested.

A large amount of loading of mines, depth charges, and bombs with high explosives was carried on at the station. Despite the fears of the authorities of the city of Newport, no untoward incident occurred throughout the war in connection with the concentration of high explosives for this loading and the loading itself.

Capt. J. K. Robison was relieved, in order that he might go to sea, on March 26, 1917, by Capt. E. L. Beach, who, also leaving for sea duty, was relieved on September 12, 1918, by Capt. M. E. Trench. The station has progressed steadily under these officers, and the advances in the torpedo have been more marked than during any other period in the Navy's history.

B—PACIFIC COAST STATION, KEYPORT, WASH.

This station was equipped only to store and overhaul torpedoes, and to effect minor repairs. During the war, the transfer of activities to the Atlantic Ocean removed most of the ships carrying torpedoes which had been based on the Pacific coast, and in consequence very little other than minor routine work was carried on at this station.

C.—TORPEDO ASSEMBLY PLANT, ALEXANDRIA, VA.

As has been noted in the chapter on torpedoes, the bureau appreciated during the war that the existing torpedo facilities in this country were not capable, even with all possible expansion, of meeting the Navy's need for torpedoes. Accordingly, in August, 1918, the purchase of a site in Alexandria, Va., and the construction of a torpedo assembly plant thereon, at a total cost of $2,760,000, was authorized, and soon begun under the direction of Capt. W. S. Miller, United States Navy.

This plant was to be able to completely assemble and test torpedoes, including machining and finishing air flasks and a number of parts.

Although the armistice was signed before the plant was completed, construction has been continued and the existence of this plant, together with other torpedo-manufacturing facilities in this country, will meet all future needs of the Navy for torpedoes which can at present be visualized.

MINE DEPOTS.

A.—NEW LONDON, CONN.

Shortly after the outbreak of the war the bureau commenced construction, on a site adjacent to the submarine base at New London, Conn., of a small mine depot for the storage of some 3,000 mines, of which existing war plans called for the concentration in that vicinity. Chief Gunner Frank C. Messenger, United States Navy, was placed in charge, and construction carried on until eleven storage buildings were completed and filled with depth charges and mines.

By that time, however, the notable advance in mining described in the chapter on the Northern Barrage had taken place, and the need was felt by the bureau for a far greater mine depot.

B.—YORKTOWN, VA.

The establishment on the Atlantic coast of a mine depot, at which practically all mining activities would be concentrated, was decided upon by the Bureau of Ordnance in the spring of 1918. There was no plant then existing in the United States where mines being manufactured could be stored, assembled, loaded, tested, and issued to the service in quantities sufficient to meet any demands of war. After a study of possible sites had been made, a tract of land about 4 miles square, in the vicinity of Yorktown, Va., was selected in April, 1918, as the best location. The considerations which led to this selection included the following:

(*a*) Yorktown is centrally situated with respect to the Atlantic coast of the United States.

(*b*) Yorktown is very accessible for naval vessels of any size or draft, being as convenient to the Chesapeake Capes as is the navy yard, Norfolk; and, while accessible, it can be most readily protected from enemy attacks of whatever description.

(*c*) Yorktown is conveniently located near the Norfolk Navy Yard, the naval operating base at Hampton Roads, and the fuel bases of the fifth naval district.

(*d*) Yorktown is located in a very sparsely inhabited district; therefore the large area of land necessary to the establishment of a mine and high-explosive depot could be obtained at a reasonable cost, and great quantities of high explosives could be stored and handled there without risk to outside life and property.

(*e*) Excellent transportation facilities could be readily developed. The area selected had a water front on the York River of about 5 miles and extended inland to the main line of the Chesapeake & Ohio Railroad.

MINE STORAGE BUILDINGS UNDER CONSTRUCTION AT NAVAL MINE DEPOT, YORKTOWN, VA.

MINES STORED IN THE OPEN AT NAVAL MINE DEPOT, YORKTOWN, VA., AWAITING COMPLETION OF STOREHOUSES.

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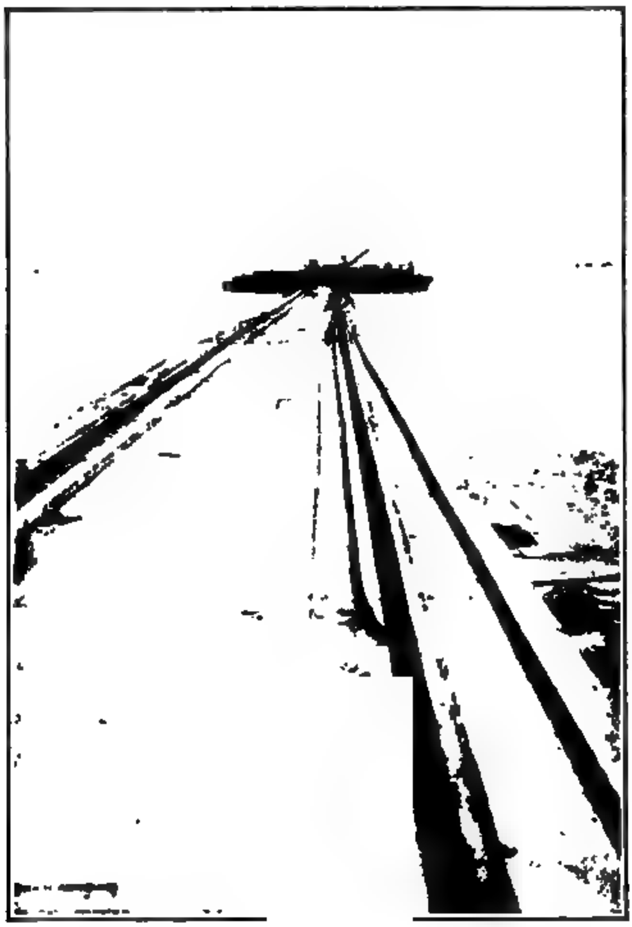
MINES RECEIVED AT NAVAL MINE DEPOT, YORKTOWN, VA. WAITING COMPLETION OF STORAGE BUILDINGS.



TEMPORARY RAILROAD PIER AT NAVAL MINE DEPOT, YORKTOWN, VA., FOR RECEIPT AND SHIPMENT OF MINES.

The title to the land for the mine depot, 11,433 acres, comprising a part of each of the counties of York, James City, and Warwick, was taken by presidential proclamation dated August 7, 1918, While it was not possible to draw up definite plans for the establishment of the depot until after the title to the land had been secured, some work had been accomplished in that direction, and construction began in September, 1918.

Although this depot was not completed during the war to such a degree as to be of any value, yet its necessity was so apparent that construction in full is being continued, and a description of this depot, built as a result of the bureau's activities in the war, may well be of interest. Commander S. P. Fullinwider, then of the Mine Section of the bureau, originated the project of such a depot, assisted in the selection of the site, and in June, 1919, was at his request transferred from the bureau to command of the depot, relieving Capt. E. T. Fitzgerald, R. F., who had commanded up to that date.

Construction of the mine depot includes a mine-loading plant, consisting of several buildings, 10 magazine buildings for the storage of high explosives, five storage buildings for mine and depth charge material, a nonmagnetic building, barracks, mess buildings, administration buildings, a pier, a power plant, a machine shop, a railroad, to connect with the Chesapeake & Ohio Railroad, vehicle roads, a telephone system, water and fire protection systems.

The five storage buildings of the depot are designed to contain more than 50,000 mines and anchors, which, except for a small supply ready for instant use, will be kept unloaded.

The 10 magazines for high explosives, each capable of storing 1,000,000 pounds, are spaced about one-half mile apart in an area 2 miles square, leaving a border of unoccupied ground about 1 mile wide on all sides, including the water front. No construction, except the railroad, was planned for this safety zone; and any possible explosion in the depot will not seriously damage adjacent property.

The pier as designed is 2,000 feet in length, allowing seagoing vessels of deep draft to come alongside. The railroad track is carried to the end of the pier in order that mine planters and other vessels may be loaded and unloaded with facility.

The cost of the mine depot will be about $3,000,000, and a special appropriation for this amount was made at the time the depot was planned.

The personnel at the mine depot comprises officers and enlisted men of the Navy and Marine Corps and additional civilian labor. All patrol and sentry duty is performed by marines.

The first carload of material to be stored at the mine depot was received the latter part of July, 1919. At that time the storage buildings were nearly completed, although much work remained in connection with the other facilities.

When the depot is complete, it will have the following activities:

(*a*) It will store about 80 per cent of all mine and depth charge material.

(*b*) In conjunction with the mine force, it will be the "mine proving ground" for practical tests and experiments.

(*c*) In conjunction with the mine force, it will be a school for instruction of officers and men in mining.

(*d*) It will be an assembly plant for loading, assembling, inspecting, testing, and issuing mines to the mine force ready for use.

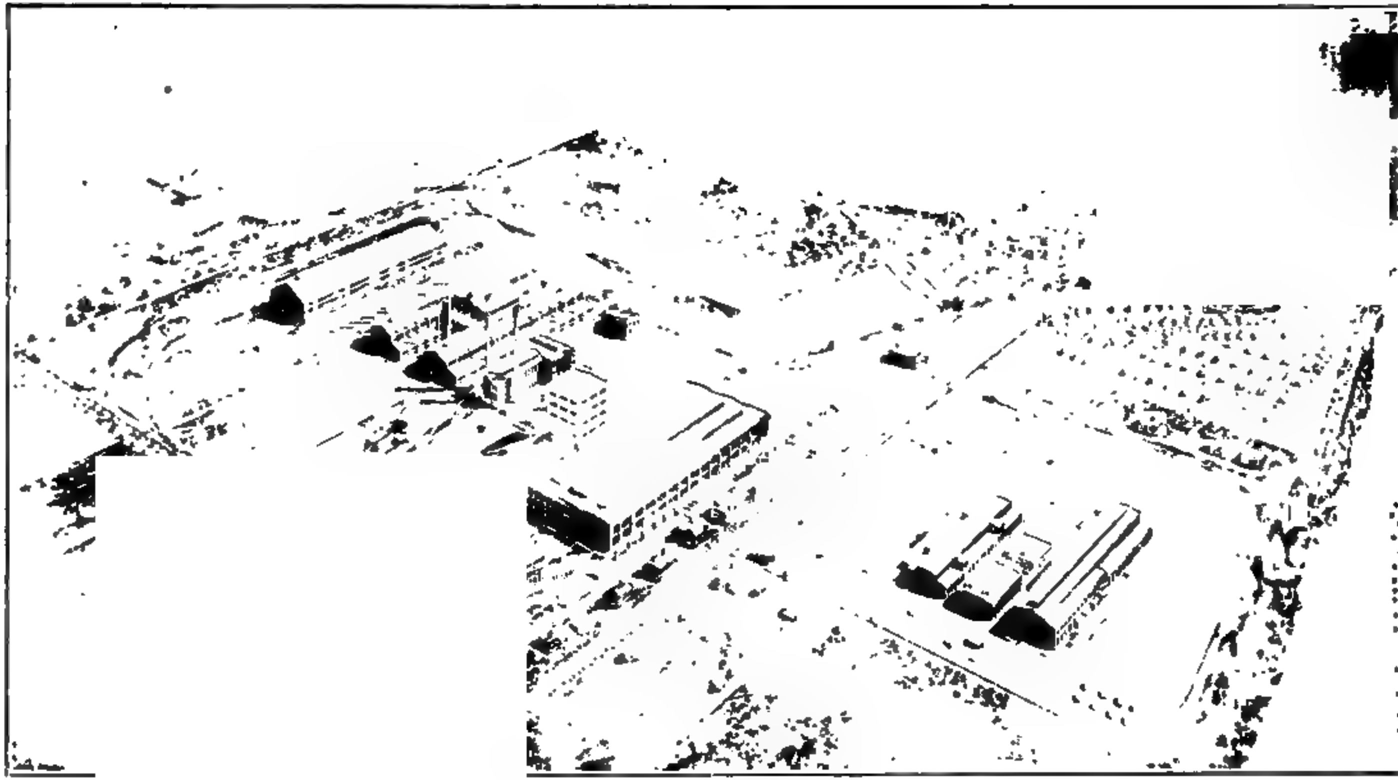
NAVAL ORDNANCE PLANT, SOUTH CHARLESTON, W. VA.

In order to provide additional facilities for the manufacture of armor for naval vessels, the Navy Department recommended some years prior to the war the construction of a naval armor plant, and Congress authorized such construction and made initial appropriations therefor. The Secretary of the Navy appointed a committee to select the site for such a plant; and, after examination of a number of suggested sites, it was decided April 24, 1917, to build the plant near Charleston, W. Va. In other words, the selection of the site of this plant was made practically coincident with the entry of the United States into the war. The complete project consisted of a single plant in which guns, armor, and armor-piercing projectiles were to be produced, with an aggregate annual capacity of approximately 40,000 tons.

Two facts were at once apparent, however; first, that due to the need of the Allies for small vessels rather than battleships, there would be no immediate expansion in battleship building by the United States, consequently no immediate need for additional armor; second, that all available capacity was urgently needed for small gun forgings.

A site containing 210.091 acres at South Charleston, W. Va., was selected for the plant. The Chamber of Commerce of Charleston, W. Va., purchased 205.391 acres of this area for the sum of $290,-845.68 and donated it to the United States. The remaining 4.7 acres was acquired by condemnation proceedings for the sum of $64,047.25, of which amount the chamber of commerce paid the sum of $19,895.32 and the remaining $44,151.93 was paid by the Government.

From the above it is disclosed that the entire area of 210.091 acres was acquired for the total sum of $354,892.93. Of this amount the



U. S. NAVAL ORDNANCE PLANT, SOUTH CHARLESTON, W. VA.

ELECTRIC FURNACE, NAVAL ORDNANCE PLANT, SOUTH CHARLESTON, W. VA.

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GUN-STEEL INGOTS MADE AT U. S. NAVAL ORDNANCE PLANT, SOUTH CHARLESTON, W. VA., WITH HERCULT ELECTRIC FURNACES, 1918 19.

258-4

GUN SHOP NAVAL ORDNANCE PLANT, SOUTH CHARLESTON, W. VA

FORGE SHOP, NAVAL ORDNANCE PLANT, SOUTH CHARLESTON, W. VA.

258-5

chamber of commerce paid $310,741 and the Government $44,151.93. The property was acquired under 56 separate deeds.

The first work undertaken on the site was the construction of the projectile plant, and while this was to bear the name "projectile plant," its use for the manufacture of projectiles was to be deferred during the war, and the plant was to manufacture small gun forgings.

As an evidence of the speed in construction, the deeds conveying the ground to the United States were not received until June 4, 1917, but awards for machine tools, hydraulic presses, pump, and electric furnaces for the projectile plant were recommended during June, 1917.

The first heat of steel in the projectile plant was successfully poured on June 8, 1918, even before the completion of the buildings on August 5.

The installation of machine tools was pushed rapidly, during July and August, 1918, and was practically completed by the end of November. Three electric steel furnaces, each of 6 tons capacity, were put in operation during June, July, and August, and this department of the plant may be considered as being on a running basis from September, 1918. Similarly, in the forging shop, the 500-ton press was started on October 2 and the 3,000-ton press on October 15, 1918, and finally the heat treatment department was put on an operating basis, sufficiently satisfactory to meet the production of the forging and hot metal departments, by August, 1918. Thus, this portion of the plant, with a capacity of approximately 10,000 tons of forgings per annum, was on a production basis about two months before the armistice was signed, and had immediately begun the production of small forgings.

Before the close of the war, the complete plans had been finished and construction work started on the final armor and gun forging plant, this to consist of four large buildings, comprising an open-hearth building, forge and furnace building, heat-treatment building, and machine shop, together with necessary accessories, smaller structures and track connection.

The open-hearth building will be 225 feet by 602 feet, and will contain four 65-ton open-hearth furnaces and three 30-ton electric furnaces. The forge and furnace building will be 462 feet by 644 feet and has been designed to turn out 20,000 tons of armor plate and 10,000 tons of gun forgings per year. The machine shop and heat-treatment building are of similar size and adequately fitted to complete the operations on this great amount of armor.

Commander J. B. Rhodes, United States Navy, assisted by Mr. Wm. J. Priestley, was in charge of the planning, construction, and

operation of this naval ordnance plant throughout the war period. At the end of the war, the plant was operating with a personnel of approximately 1,000, and had delivered a large amount of ordnance material to the Navy. This plant will be a large factor in future improvements in quality of steel, armor, and gun forgings. Its operation is an absolute necessity in order to meet the demands of the Navy's building program not only as to armor but also as to its major caliber guns. All departments of the plant should be in operation by July, 1921.

CHAPTER XVIII.

EPILOGUE.

In glancing back over this record of the work of the bureau during the days of this war of 1917, it appears that the real worries and anxieties have not been as vividly pictured to the reader as we would desire. The strenuous days and nights when the task confronting us to supply proper and sufficient ordnance material to the Navy seemed well nigh impossible, the obstacles confronted—the lack of technical officers, insufficient supplies and office space, the coal shortage, the hard winter of 1917–18, the violent epidemic of influenza, all these and more—must be experienced in order to realize what it meant. A perusal of the chapters might lead one to believe that a certain gallant old seaman is correct when he states, "The mountains of the present are the molehills of the past"; yet those who were in positions of responsibility during this period can not entirely agree with him.

That the Navy did prepare for war more quickly than had been thought possible by professional men was due in great measure to several favorable conditions; the most important of which will never obtain conceivably again. This was the fact that, since August, 1914, many large plants had come into being for the manufacture of munitions of all types for the Allies fighting across the water. These plants, but mainly their personnel, since tools are but toys without the competent machinist and the administrator, could be and were quickly utilized to expand present and create new facilities for the United States.

Huge plants had been created for, or converted to, munition work before the United States entered the war. True, their capacity was needed for the Allies and could not be used for the United States needs. But the experience of the administrators, the skill of the artisans, had been gained, and proved a sure foundation on which to upbuild the further expansion of munition facilities required for our own forces. For instance, the powder and high-explosive industries were in a condition that, save for the manufacture of synthetic nitric acid, could and did meet every demand. The great automobile industry proved a valuable source of the more readily manufactured and assembled material. The steel industry had turned largely from commercial products to munitions and was ready to take care of the

United States' demands; yet, even with such experience, high-grade steel for guns, mounts, and projectiles proved difficult to obtain, especially the cumbersome heavy steel castings for gun mounts and, most difficult of all, gun forgings.

But these plants, operating on munition work before 1917, were working on foreign material, and for the greater part material for armies in the field. When it came to naval ordnance material there was yet a wide gap to be bridged.

In the bridging of this gap, the main factor that helped the Navy ordnance was the existence of the ordnance plants of various kinds and the shops and facilities existing in navy yards. Immediate use could be made of these.

Additional similar industrial ordnance plants had to be established. Who could train the men required to operate them, or who could design the plant and purchase the machinery? None but those experienced in similar lines. Hence the Navy's ordnance plants were early mulcted of every man that could possibly be spared, with the result that private plants did get going and got going on time, and their output actually went into action on ship and on shore against the enemy, even though the war did last but 18 months. This record, in case of guns especially, could never have been accomplished but for the Navy's ordnance plants, primarily the Naval Gun Factory, located in Washington, D. C. As is stated in the Oliver report to Congress—the result of an investigation into the conduct of the Navy's affairs conducted in March, 1918—"without direct control of the gun factory, torpedo stations, naval proving ground, powder factory, and ammunition depots, the work accomplished would have been impossible." This truthful statement can never be too strongly emphasized. The importance of the Navy's controlling certain industrial plants engaged in work of the peculiar kind necessitated by warfare afloat was exemplified time and again.

The lesson of all this is that the naval ordnance plants should not only continue to operate, but should take on and employ in peace time many supernumeraries in order that trained men along the intricate lines of steel, shell, machine work, forging, and so on, may be available in greater numbers when the need comes. We may not again have several years of preparation in the industries of the country for war production, as we did in the two and one-half years prior to our entry into the war in 1917.

Parallel to the industrial expansion of munition-producing facilities, or rather in advance of it, there must be an organization capable of directing such great forces. As the Navy is the first line of defense, and first called upon, it must be constantly ready, both in its fleet and in the shore establishment necessary to maintain the fleet.

The Navy feels that its theory of organization, whereby its peacetime duties are administered exactly as all the wartime requirements must be, was vindicated, is sound, and can not safely be departed from. The bureau adhered to this principle, and never changed its basic organization. Despite the ten-fold enlargement of its responsibilities, it never acquired a large personnel in its executive positions. Each officer was loaded to capacity before an assistant was called in. Thus, no massive organization was built up; the inertia of such bodies is hard to overcome, slow to start, and difficult to control after once moving. The word "slow" had to be eliminated from the Navy's work. The first line of defense had to be provided with offensive and defensive weapons "immediately." The bureau could not wait, it had to move. The results justify the belief that its principles of organization and administration were correct and require no change whatsoever.

The method of organization was also efficient in stimulating production. The bureau inspectors, always in charge of seagoing but specialized technical officers, not only inspected material—that was the least of their duties in the strenuous days—but taught new firms how to produce not only the required quality, but, in addition, how to increase the quantity. As but one concrete example out of many similar ones of what training means, we have the fact that one lieutenant commander from the bureau actually and personally made the gun steel and forgings at one plant before that industrial plant could produce the kind of steel that ordnance had to have.

The experience of the war clearly shows that no change whatever should be made in the bureau's methods—the training of officers and men for ordnance duties (save to increase their numbers and the scope of their education); the manner of carrying out work in the field; and the coordination with the fleet. The bureau earnestly hopes that seagoing trained and specially educated technical officers will always be retained in its shore functions. No permanent shore-duty officers can or will give such a good account of themselves. Design and inspection must always be in charge of the seamen who depend upon the tools they produce to carry them through the times of stress and danger, else we invite disasters of a type from which the Navy has so far fortunately been free.

As a rule, the relations between the bureau and the contracting firms were most cordial and frank. The firms gave willing adherence to our plans and specifications. The war has again proven how sound is the foundation upon which our specifications for material rest; these materials withstanding all the tests of war.

The officers of the bureau, and of its ordnance stations and inspection districts, officers both regular and reserve, conducted their

duties efficiently and did more than could have reasonably been required of them. The bureau is well satisfied with the ability, energy, and loyalty of all hands, and with the initiative and skill shown in their multitudinous tasks.

The bureau is glad to testify also to the zeal, support, and invaluable assistance of its long service civilians in the bureau, at the plants and in the inspection service; they cheerfully took the heavy load thrust upon them by the demands of war, and furthermore whipped into shape the new personnel, obviously unacquainted with the Navy's and the bureau's requirements. No less credit attaches to the newer enlisted and civilian personnel who assimilated and performed their duties with enthusiasm and ability. Every commendation is due them and is here given.

In addition to their regular duties, at all points the ordnance personnel met alike in the same hearty responsive manner the calls for material or for aid in Liberty loans, War Savings stamps, Red Cross contributions and other essential war activities.

Of those who made the work of the Bureau of Ordnance during the war a *go*, some have remained in the service, some are at sea, but the great majority are now absent in other fields of work in civilian life, and so it is considered appropriate to insert opinions of a few of the leading officials with whom the bureau dealt as to the kind of work accomplished during the war.

(1) From the Secretary of the Navy:

JANUARY 14, 1918.

I have read with the greatest pleasure and satisfaction the statement given to the press by the Hon. Wm. B. Oliver, chairman of the subcommittee of the Committee on Naval Affairs, which has been examining into the work of the Navy Department since the declaration of war. This statement, made after thorough and exhaustive study of the work of the Ordnance Bureau under your direction, will give the country a feeling of confidence and assurance. It has been a matter of the greatest comfort to me during all these months of stress and strain to know day by day of the thoroughness of the work of the Bureau of Ordnance, of the zeal and efficiency of the entire force, and to admire the spirit of investigation and accomplishment which made possible the conclusion reached by the special committee of the House of Representatives. I wish you and all in the Ordnance Department to be assured of my high appreciation of the wonderful things that have been done. I rejoice that it has been made known to the whole country.

Sincerely yours,
JOSEPHUS DANIELS.

(2) From the Chief of Naval Operations:

JANUARY 12, 1918.

* * * * * * *

The Chief of Naval Operations wishes to congratulate the Bureau of Ordnance * * * upon the success which the bureau is achieving in its many fields of activity. * * * It is noted that in many cases where the depart-

ment considers a degree of deliberation necessary the plans of the bureau have not materialized due to delays, but, considering the total work, the Chief of Naval operations feels that the bureau may be justly proud of its accomplishments and of its prospects for the immediate future.

W. S. BENSON.

(3) From Admiral Sims:

DECEMBER 29, 1918.

Your letter of December 10 just received and I thank you very sincerely for your flattering references to that little we have been able to do to help along the very efficient work of the Ordnance Department.

I am quite sure we have had no occasion to be impatient with delays, and so forth, because I believe we have thoroughly understood the great difficulties with which you were confronted.

On the contrary, it has been a matter of some surprise to us that you have been able to put through so many stunts in such a short time. I can not recollect any request that we have made for ordnance material or equipment that has not been complied with immediately, and it is my opinion that we are much more beholden to you and your bureau for war service than you are to any of us.

With my best wishes for a happy and successful New Year to you and your band of efficient assistants,

Believe me, always very sincerely yours,

SIMS.

(4) From the commander, mine force:

MARCH 29, 1919.

I beg to furnish for the files of the Navy Department an expression of appreciation of the part played by the Bureau of Ordnance in the construction of the mine barrage in the North Sea.

The mine itself, though entirely novel, was highly successful in its functioning, and this, I understand, was devised in the bureau in a comparatively short time. The call for mines for the North Sea barrage, that in the Aegean Sea, and across the Adriatic, would have amounted in the end to probably 130,000. We actually received at the North Sea bases some 80,000 mines, and used 57,000. We would have used more there had not the war been brought to a close when it was. We were amply supplied, and at no time was the expedition compelled to wait for material. The task placed on the Bureau of Ordnance was a very great one, and the highest credit is due the bureau for its achievements.

J. STRAUSS,
Rear Admiral, U. S. N.

(5) As indicating that the bureau's endeavors to meet manufacturers half way had met with some measure of success, the following from a letter written to the Hon. Isaac R. Sherwood, M. C., under date of March 9, 1918, by the Spencer Engineering Co., of Toledo, Ohio, was of great satisfaction to the bureau's officers:

This company has a contract with the Navy Department for the manufacture of 300,000 antiaircraft shells, which is progressing nicely toward completion.

Our contract has been pending for several months, and it has been necessary, of course, for us to keep in constant touch with the Navy Department, and to that end it has been the duty of the writer to make several trips to Washington

and to interview and consult with the officers and others in the Bureau of Ordnance of the Navy Department.

In view of the fact that there has, in the past, been much criticism of the different Governmental departments, we feel that it is only just and right that we should state to you that we have never received more courteous, fair, and business-like attention and treatment than we have received from the Bureau of Ordnance.

While it has been manifest at all times that the first consideration in the minds of those in charge of the department is the interest and welfare of the Government, yet it has also been equally clear that they deal considerately and fairly with parties having business with the bureau.

We doubt whether there is a business concern, large or small, in the country that has a more efficient organization than is found in the Bureau of Ordnance of the Navy Department, and, indeed, our dealings with the bureau have been much more pleasant and satisfactory than dealings we have had in the past with many large concerns.

If at any time in the future there is any criticism or investigation where these matters might be pertinent, we wish you would bear our experience in mind.

Letters such as the foregoing are inserted, primarily, for the satisfaction of those who have left the bureau since the war, in the way of a testimonial to show them in the future years how they performed the tasks given them, and made good. These men and women, as well as those still remaining in the service, must always feel a pride and a comfort in such testimonials to their work.

The days to come for the bureau and its personnel are days of building guns and like material all ever better than before, of constructing the armament for our newest ships, of development of the multitude of devices for fire control, and of aiding the Navy to keep alive the spirit of its great leaders, and to keep its vessels always possessed of the best fighting materials the ingenuity of man can devise. Our work is in nowise completed. The Navy as the nation's first line of defense and offense requires, in the future as in the past, the whole-hearted, progressive, and efficient support of its entire personnel in all lines, and ordnance will continue to play a large part in its future efficiency.

APPENDICES.

I. Chronology.
II. Officers and civilian employees of the bureau.
III. Duties of sections of the bureau in brief.
IV. Personnel of plants and inspection force.
V. Table showing personnel of bureau during the war, at the time of signing the armistice, and November 1, 1919.
VI. New plants erected.
VII. Ordnance production, contracts and deliveries.
VIII. Miscellaneous data.

APPENDIX I.

WORLD WAR HISTORICAL DATES OF INTEREST TO BUREAU OF ORDNANCE.

1916.

Mar. 24. The French steamer *Sussex* was torpedoed by a German submarine without warning; 80 passengers, including some American citizens, being killed or wounded.

May 4. Germany pledges itself to adhere to the laws of war at sea.

31. Battle of Jutland.

Oct. 28. British steamer *Marina* sunk without warning, six Americans being lost.

Dec. 7. Fall of Asquith Ministry. Lloyd George new prime minister.

18. American peace note issued.

1917.

Jan. 22. The President outlines the steps necessary to secure world peace.

31. Germany announces unrestricted submarine warfare in certain zones.

Feb. 3. United States severs diplomatic relations with Germany, her ambassador, Von Bernstorff, being dismissed. Bureau of Ordnance's orders for movement of guns issued.

26. The President asks authority to arm merchantmen.

Mar. 4. Three hundred and fifty subchasers authorized. Additional destroyers taken in hand.

12. United States announces that all American merchantmen sailing through the war zone will be armed. Revolution in Russia.

13. First directions assigning guns to merchantmen issued by bureau.

15. Batteries completely installed on steamships *Manchuria*, *St. Louis*, and *Aztec*. Midnight, Czar Nicholas abdicates on behalf of himself and son in favor of his younger brother. Grand Duke Michael.

16. *Manchuria* sails, she being the first armed merchantman to sail for a port in war zone.

26. Steamship *St. Louis*, later *Louisville*, the first armed merchantman to reach a port in war zone, arrives at Liverpool.

31. The Danish West Indies are formally transferred to the United States.

Apr. 1. Steamship *Aztec*, second armed merchantman that sailed, sunk off Ushant, 9 p. m.

6. United States declares war exists between it and Germany.

8. Austria-Hungary severs diplomatic relations with the United States.

9. General munitions board of the Council of National Defense formed.

19. At 5.23 a. m. the after 6-inch gun No. 263 on the *Mongolia* fired the first United States naval shot of the war. This shot is thought to have hit and damaged a German submarine.

May 4. The destroyers *Wadworth*, *McDougal*, *Porter*, *Wainwright*, *Conyngham*, and *Davis* arrive off Queenstown, Ireland, and begin offensive operations against German submarines in cooperation with the British.

1917.

May 14. The priority committee of Council of National Defense formed.

20. Accident on steamship *Mongolia* during gun trials, two Red Cross nurses being killed.

June 12. The Northern Barrage project formally submitted to the department.

26. Our first troops, including marines, land at St. Nazaire, France.

July 5. Steamship *Navajo* sinks a submarine.

13. Destroyer *Warrington* successfully attacks a submarine.

18. The announcement made of success of the new mine adopted for barrage purposes.

28. Formation of War Industries Board.

30. The bureau submits the plan, finally adopted, for the Northern Barrage.

Aug. 6. Steamship *Campana* defeated in an engagement with a submarine.

Oct. 6. Destroyer program for some 300, and additional subchaser program of 41, adopted. Congress passes a law authorizing advance payments to private firms.

19. Steamship *Luckenbach* successfully engages a submarine.

24. Italians driven back at Caporetto by the German-Austrian drive that extends to the Piave.

29. The Northern Barrage project approved.

Nov. 17. Navy supplies Italy with 5-inch 51-caliber guns for defense of Venice and for use on her Piave front.

8. Bolshevists secure control of government in Russia.

12. Railway batteries of 14-inch 50-caliber naval guns suggested.

13. Capt. O. G. Murfin, United States Navy, sailed, and established mine bases at Invergordon and Inverness.

17. Destroyers *Fanning* and *Nicholson* capture a submarine.

26. Five naval 14-inch 50-caliber railway batteries authorized.

Dec. 6. Russia withdraws from the war.

6. Destroyer *Jacob Jones* sunk by submarine.

6. Explosion of French steamer *Mont Blanc* in Halifax Harbor kills 1,500 and injures 4,000 persons, with total monetary damage of $45,000,000 to city.

6. Division of battleships, under Rear Admiral Rodman, arrived Scapa Flow.

7. United States declares war on Austria-Hungary.

9. British capture Jerusalem.

17. A torpedo repair base established at Queenstown, Ireland.

28. Government takes over operation of all railroads.

1918.

Jan. 16. All manufacturing plants ordered to close January 18 to 22, and during the nine subsequent Mondays in order to relieve fuel shortage.

31. United States troops occupying front line trenches.

Feb. 9. American flag hoisted at mine base, Inverness.

12. American flag hoisted at mine base, Invergordon.

13. Orders of January 16, 1918, closing down manufacturing plants modified to permit ordnance work to proceed.

13. Awards for 14-inch 50-caliber railway mounts made.

Mar. 11. Report of Oliver committee made to the House of Representatives on Navy administration.

1918.

Mar. 21. The great offensive of the German Army commences on line from Arras to La Fere, a 50-mile front. Long range gun bombards Paris.

29. Marshal Foch chosen as General in Chief of all allied forces.

Apr. 1. Rear Admiral Joseph Strauss, United States Navy, proceeds overseas to take charge of mining operations.

11. American steamer *Lake Moor* transporting mine material to our bases sunk in Irish Sea.

14–May 2. U. S. S. *Baltimore* lays a mine field for British Navy in North Channel, Irish Sea.

22. Naval raid on Zeebruggee and Ostend.

25. First 14-inch 50-caliber railway mount completed by Baldwin Locomotive Works, bettering their estimate for May 15.

30. This mount successfully tested at Sandy Hook.

May 9. Second naval raid on Ostend.

25. Last of the five 14-inch 50-caliber railway mounts finished.

26. Mine force under Capt. Belknap reaches our overseas bases.

29. Soissons lost.

31. Germans reach the Marne.

June 8. Forty-seven miles of American mines planted by six American mine layers.

10. The Second Division, which included our marines, at Belleau Wood pierce German line two-thirds of a mile on a 600-yard front. Allied counteroffensive begins.

12. German advance practically stopped.

20. First shipment of railway battery on steamship *Newport News* from Philadelphia.

July 6. Americans attack Chateau-Thierry.

15. Second battle of the Marne.

16. Execution of Czar Nicholas of Russia.

19. United States cruiser *San Diego* sunk.

21. Chateau-Thierry occupied by French and Americans.

29. One complete mine barrier for 230 miles across North Sea finished.

Aug. 2. Soissons recovered.

15. All railway battery material reaches St. Nazaire. France.

18, 19. Battery for front left each day.

Two battleships, under Read Admiral T. S. Rodgers, arrived Berehaven.

27. Torpedo station at Alexandria, Va., commenced.

Sept. 6. First firing by naval railway battery against Germans from Rethondes on Tergnier. At this time the battery occupied the same position later used by the train carrying Marshal Foch and staff when the armistice was signed on November 11, 1918.

12. American attack at St. Mihiel.

Oct. 26. Last mine-laying excursion on northern barrage.

30. Bulgaria withdraws from the war.

Nov. 3. Austria agrees to the armistice terms of the Allies.

4. Hostilities with Austria ceased.

9. The Kaiser and Crown Prince of the German Empire abdicate.

11. Monday, at 10: 57.30 a. m., last shot from naval railway battery fired on Longuyon from Charny. At 11 a. m. all hostilities ceased, Germany having yielded and signed the terms of the armistice drawn up by Allies.

1918.

Nov. 14. Allied fleet anchors off Constantinople.

20. The first 20 German U-boats surrendered to the British cruisers and destroyers, under Admiral Tyrwhitt, off Harwich.

21. German battle fleet surrenders off Firth of Forth, Scotland, to British and American battle fleet.[1]

22. German fleet, under strong escort, sailed for Scapa; there to be interned under guard of the British Navy.

1919.

June 21. The interned German fleet at Scapa Flow is sunk by its crews.

28. (10 a. m., United States time; 3.12 p. m., Paris time), representatives of the Allied and Associated powers signed the treaty of peace with Germany at Versailles.

Sept. 10. Austria signs treaty of peace with the Allies and Associated powers at St. Germain.

Oct. 31. Up to this date the treaty of peace with Germany had been ratified by Great Britain, France, and Italy.

1920.

Jan. 10. Exchange of ratification of treaty at Paris by Germany and Allies.

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[1] For details see pp. 89–97, U. S. Naval Institute Proceedings, No. 191.

APPENDIX II.

NAVAL AND CIVILIAN PERSONNEL OF THE BUREAU OF ORDNANCE, APR. 6, 1917, TO NOV. 11, 1918.

OFFICE OF CHIEF OF BUREAU.

Rear Admiral Ralph Earle, U. S. Navy	Entire period.
Clerk H. S. Miner	Until Dec. 15, 1917.
Clerk Arthur D. Wilroy	From June 4, 1917.
Clerk Mayme E. Smith	From Dec. 11, 1917.
Clerk Kathryn Thomas	From Nov. 6, 1918.

ENLISTED PERSONNEL.

Yeo. (F.) 2 cl. E. M. Nelson	From Oct. 5, 1918.
Yeo. (F.) 3 cl. A. M. Govenor	From Oct. 16, 1918.
Yeo. (F.) 3 cl. M. D. Lewis	From Sept. 24, 1918.
Lds. for Yeo. (F.) V. Black	Oct. 4 to Oct. 11, 1918.
Lds. for Yeo. (F.) M. E. Sliss	Sept. 18 to Oct. 10, 1918.
Yeo. 1 cl. J. M. O'Connell	Nov. 1, 1917, to Oct. 16, 1918.
Yeo. 1 cl. J. Joffe	July 5 to Oct. 4, 1918.
Yeo. 1 cl. M. V. Clawson	Aug. 1 to Oct. 9, 1918.
Yeo. 2 cl. W. J. Grissam	From Sept. 18, 1918.
Yeo. 3 cl. H. A. Kerwin	May 12, 1917, to Sept. 20, 1918.

OFFICE OF ASSISTANT TO CHIEF OF BUREAU.

Capt. T. A. Kearney, U. S. Navy	Entire period.
Chief Gunner R. E. Cox, U. S. Navy	From Apr. 18, 1918.
Clerk P. E. Buehler	Entire period.

CHIEF CLERK'S OFFICE.

Chief Clerk E. S. Brandt	Entire period.
Clerk H. M. Klee	Do.
Clerk C. G. Farling	From Oct. 22, 1917.
Clerk Mildred J. Catlett	From Mar. 12, 1918.
Clerk Ruth S. Erb	From July 29, 1918.
Copyist John Hands	Until April 28, 1918.
Janitor T. A. Wright	Entire period.
Laborer J. G. Willis	From July 19, 1917.
Messenger E. C. Smith	Until Aug. 23, 1918.
Messenger C. A. Ashton	From Aug. 23, 1918.
Messenger G. Hynson	From March 20, 1918.
Messenger H. R. Billups	Until May 7, 1918.
Messenger Samuel Brownfield	Nov. 12, 1917, to May 25, 1918.
Messenger Augustus Cotterill	May 2 to Aug. 19, 1918.
Messenger James R. Duncan	May 22 to June 30, 1917.

Messenger James A. Lennon	July 25, 1917, to Mar. 9, 1918.
Messenger Roy A. McMullan	Nov. 6 to Dec. 18, 1917.
Messenger Wm. Parrott	Oct. 29, 1917, to Jan. 28, 1918.
Messenger Meril Pumphry	July 23 to July 30, 1917.
Messenger DeWitt Stephens	June 11 to Sept. 21, 1918.
Messenger John F. Thornton	July 12 to Sept. 19, 1918.
Messenger Albert F. Watson, jr	Until May 21, 1917.
Messenger Howell Harris	From Nov. 13, 1917.
Messenger James H. Willock	Feb. 14 to Feb. 23, 1918.

ENLISTED PERSONNEL.

Ch. Yeo. (F.) F. M. Quigley	From May 1, 1917.
Yeo. (F.) 1 cl. B. M. Rigby	From Jan. 24, 1918.
Yeo. (F.) 1 cl. M. J. Catlett	April 16, 1917, to Mar. 11, 1918.
Yeo. (F.) 3 cl. M. E. Tribble	From Sept. 18, 1918.
Yeo. (F.) 3 cl. A. W. Culp	Do.
Yeo. (F.) 3 cl. G. E. Clarke	From Sept. 13, 1918.
Yeo. (F.) 3 cl. L. J. Higgs	From Sept. 18, 1918.
Yeo. (F.) 3 cl. M. E. Ives	From Sept. 6, 1918.
Yeo. (F.) 3 cl. R. J. Reed	From Sept. 17, 1918.
Ch. Yeo. L. W. Guise	From July 19, 1918.
Ch. Yeo. E. J. Keefe	May 22 to Oct. 22, 1918.
Yeo. 1 cl. R. J. Schmidt	April 1 to Sept. 18, 1918.
Yeo. 2 cl. H. Albaugh	Jan. 19 to Feb. 18, 1918.
Yeo. 3 cl. H. G. Scheitlin	Dec. 8, 1917, to Oct. 11, 1918.
Yeo. 3 cl. R. B. Duckett	May 11 to May 24, 1917.
Sea. 2 cl. F. Marcey	Mar. 19 to Oct. 4, 1918.
Sea. 2 cl. C. G. Miller	Dec. 28, 1917, to Feb. 16, 1918.
Storekeeper 3 cl. L. L. America	From Mar. 1, 1918.
Fireman 3 cl. R. White	From June 19, 1918.
Lds. for Yeo. K. W. Clark	May 11, 1917, to Oct. 23, 1917.
Lds. for Yeo. M. S. Barr	Oct. 31, 1917, to Feb. 21, 1918.
Lds. for Yeo. G. A. Smoot	May 16, 1917, to Apr. 11, 1918.
M. Att. 3 cl. J. S. Bailey	June 13 to Aug. 23, 1918.
M. Att. 3 cl. J. Cathern	From Mar. 14, 1918.
M. Att. 3 cl. R. Fields	From June 8, 1918.
M. Att. 3 cl. M. D. Fletcher	From Dec. 18, 1917.
M. Att. 3 cl. A. A. Frazier	From Aug. 3, 1918.
M. Att. 3 cl. J. Graham	From July 8, 1918.
M. Att. 3 cl. T. Hampton	From April 3, 1918.
M. Att. 3 cl. R. W. Merritt	From Mar. 6, 1918.
M. Att. 3 cl. A. Roberson	June 8 to Oct. 16, 1918.
M. Att. 3 cl. E. J. Sampson	From Sept. 3, 1918.
M. Att. 3 cl. T. Sawyer	From Mar. 7, 1918.

FINANCIAL SECTION.

Chief Financial Clerk W. W. Werntz	Entire period.
Assistant Financial Clerk F. S. Ray	Do.
Clerk James D. Dickson	May 1 to July 15, 1917.
Clerk Agnes Gerald	From Apr. 23, 1918.
Clerk Morris Goldman	From Aug. 22, 1918.
Clerk Lewis E. Pratt	Apr. 9 to May 22, 1917.

Clerk Georgia L. Ritchie	June 14 to June 23, 1918.
Clerk Earle R. Strong	May 16 to Aug. 16, 1917.
Clerk John I. Sullivan	From Nov. 13, 1917.
Messenger Warren B. Stoll	From July 30, 1917.

ENLISTED PERSONNEL.

Yeo. (F.) 1 cl. A. M. Tully	Apr. 4 to Oct. 4, 1918.
Yeo. (F.) 3 cl. F. Cobb	From Oct. 16, 1918.
Yeo. (F.) 3 cl. G. T. Davenport	From Oct. 2, 1918.
Yeo. (F.) 3 cl. A. Gerald	May 17, 1917, to Apr. 22, 1918.
Yeo. (F.) 3 cl. S. E. Hagan	From Sept. 12, 1918.
Yeo. (F.) 3 cl. J. P. Miller	From Sept. 20, 1918.
Yeo. (F.) 3 cl. S. Paas	From Oct. 16, 1918.
Yeo. (F.) 3 cl. M. A. Shonlau	From Oct. 26, 1918.
Lds. (F.) for Yeo. E. C. Hoffmaster	Oct. 2 to Nov. 6, 1918.
Ch. Yeo. W. G. Shreve	From June 4, 1917.
Yeo. 1 cl. H. W. Schmidt	Apr. 1 to June 5, 1918.
Yeo. 1 cl. H. J. Balzer	From July 22, 1918.
Yeo. 1 cl. F. P. Crawford	Do.
Yeo. 1 cl. B. L. McGarvey	Do.
Yeo. 2 cl. P. S. Guinn	Feb. 1 to July 19, 1918.
Yeo. 2 cl. E. J. McHale	Apr. 4 to July 19, 1918.
Yeo. 2 cl. J. R. Tyrrell	From June 10, 1918.
Yeo. 3 cl. M. H. Golden	From June 3, 1918.
Yeo. 3 cl. C. R. Kuenzli	Oct. 16, 1917, to Oct. 26, 1918.

FILES AND RECORD SECTION.

Chief File Clerk T. S. Scrivener	Entire period.
Clerk A. S. Brown	Do.
Clerk H. M. Slicer	Do.
Clerk D. P. Scott	To June 24, 1918.
Clerk F. W. Stump	Entire period.
Copyist E. T. Offutt	Do.
Clerk M. Lundrigan	From Sept. 3, 1918.
Clerk D. R. Neisuler	From Oct. 14, 1918.
Clerk F. Cudlip	Sept. 12, 1917, to June 14, 1918.
Clerk D. C. McCleery	Until Apr. 30, 1917.
Clerk Troy E. Hill	Until June 24, 1918.
Clerk Sarah M. Gantley	From Oct. 1, 1917.

ENLISTED PERSONNEL.

M. at Arms (F.) 2 cl. K. McMahon	From Jan. 17, 1918.
Yeo. (F.) 2 cl. A. L. Dillon	From Sept. 5, 1918.
Yeo. (F.) 3 cl. E. G. Cornwell	Do.
Yeo. (F.) 3 cl. D. I. Dankmeyer	From May 31, 1918.
Yeo. (F.) 3 cl. E. Farrell	From June 13, 1918.
Yeo. (F.) 3 cl. M. V. Fraser	From May 14, 1917.
Yeo. (F.) 3 cl. O. V. Giovannoni	From July 29, 1918.
Yeo. (F.) 3 cl. L. M. Hockman	From Aug. 8, 1918.
Yeo. (F.) 3 cl. L. M. Howell	From Sept. 24, 1918.
Yeo. (F.) 3 cl. R. M. Keenan	From Sept. 6, 1918.

Yeo. (F.) 3 cl. K. E. Lynch ---------- July 27 to Sept. 9, 1918.
Yeo. (F.) 3 cl. D. C. Michael ---------- From Aug. 12, 1918.
Yeo. (F.) 3 cl. E. T. Myers ---------- From July 25, 1918.
Yeo. (F.) 3 cl. M. F. Nixon ---------- From Aug. 7, 1918.
Yeo. (F.) 3 cl. R. D. Nunn ---------- From Aug. 2, 1918.
Yeo. (F.) 3 cl. R. E. Rupertis ---------- From Aug. 19, 1918.
Yeo. (F.) 3 cl. M. A. Sensel ---------- From Sept. 5, 1918.
Yeo. (F.) 3 cl. B. M. Sherry ---------- From Aug. 2, 1918.
Yeo. (F.) 3 cl. B. Walter ---------- From Aug. 3, 1918.
Yeo. (F.) 3 cl. E. L. Wilson ---------- From Aug. 22, 1918.
Lds. (F.) for Yeo. C. E. Cook ---------- From Oct. 24, 1918.
Lds. (F.) for Yeo. G. Cusack ---------- From Sept. 18, 1918.
Lds. (F.) for Yeo. A. E. Havener ---------- Sept. 6 to Oct. 25, 1918.
Lds. (F.) for Yeo. D. C. Higgs ---------- From Oct. 1, 1918.
Lds. (F.) for Yeo. B. M. Hoffman ---------- From Sept. 11, 1918.
Lds. (F.) for Yeo. B. O. Imlay ---------- From Sept. 18, 1918.
Lds. (F.) for Yeo. K. S. O'Kane ---------- From Oct. 18, 1918.
Lds. (F.) for Yeo. I. L. Kilby ---------- From Sept. 6, 1918.
Ch. Yeo. W. C. Cheely ---------- July 1 to Oct. 9, 1918.
Ch. Yeo. D. P. Scott ---------- From June 25, 1918.
Yeo. 1 cl. J. J. Daly ---------- From July 9, 1918.
Yeo. 2 cl. M. B. Goldberg ---------- Oct. 31, 1917, to Feb. 4, 1918.
Yeo. 2 cl. T. E. Henderson ---------- From July 16, 1918.
Yeo. 2 cl. K. S. Miller ---------- From Apr. 30, 1917.
Yeo. 2 cl. H. V. Pugh ---------- From Dec. 7, 1917.
Yeo. 2 cl. U. K. Rice ---------- Jan. 23 to June 27, 1918.
Yeo. 2 cl. P. A. Trapier ---------- May 15, 1917, to July 29, 1917.
Yeo. 2 cl. J. H. Williamson ---------- Apr. 28, 1917, to Oct. 4, 1918.
Yeo. 2 cl. W. E. Woolsey ---------- From Oct. 15, 1917, to Dec. 17, 1917.
Yeo. 3 cl. A. P. Irving ---------- From June 27, 1918.
Yeo. 3 cl. W. B. Cummings ---------- Oct. 16, 1917, to Jan. 23, 1918.
Yeo. 3 cl. J. M. French ---------- From May 8, 1917, to Jan. 23, 1918.
Yeo. 3 cl. G. M. Jacobs ---------- Jan. 4 to Aug. 26, 1918.
Yeo. 3 cl. J. J. Malone ---------- May 24, 1917, to June 26, 1918.
Yeo. 3 cl. J. L. Pearle ---------- From Apr. 29, 1918.
Yeo. 3 cl. D. M. Stith ---------- May 21, 1917, to Dec. 17, 1917.
Yeo. 3 cl. E. Waggy ---------- From Mar. 25, 1918.
Yeo. 3 cl. G. E. Wilson ---------- Aug. 3 to Sept. 27, 1918.
Yeo. 3 cl. S. H. Wilson ---------- Feb. 8 to Sept. 27, 1918.
Sea. 2 cl. B. Holland ---------- Dec. 31, 1917, to Mar. 5, 1918.
Sea. 2 cl. E. E. Harrington ---------- Jan. 21 to June 26, 1918.
Sea. 2 cl. C. E. Kelly ---------- From Jan. 25, 1918.
Sea. 2 cl. L. M. Pugh ---------- Dec. 7, 1917, to June 15, 1918.
Sea. 2 cl. G. E. Wire ---------- Mar. 20 to July 10, 1918.
Lds. for Yeo. B. Inge ---------- Apr. 27, 1917, to Sept. 27, 1918.
Lds. for Yeo. R. D. Trussell ---------- Apr. 30, 1917, to Oct. 11, 1918.

REQUISITION SECTION.

Chief Requisition Clerk Frank B. Blackburn -- Entire period.
Clerk H. W. Matsen ---------- Do.
Clerk G. E. McGavin ---------- From Sept. 24, 1917.
Clerk Emma Kaech ---------- From Oct. 15, 1917.
Clerk Golda Bancroft ---------- From Apr. 18, 1918.

ENLISTED PERSONNEL.

Yeo. (F.) 3 cl. E. L. Estep	Apr. 16 to Oct. 22, 1917.
Yeo. (F.) 3 cl. S. D. Peek	From Sept. 24, 1918.
Yeo (F.) 3 cl. R. Steele	Do.
Yeo. 3 cl. A. G. Romjue	Mar. 30 to Oct. 14, 1918.

MAILING SECTION.

Clerk F. Stephenson	From Oct. 16, 1918.
Clerk Samuel Karmel	Until June 30, 1918.
Messenger John F. Keady	From July 30, 1917.

ENLISTED PERSONNEL.

Ch. Yeo. F. S. Hudson	From May 1, 1917.
Yeo. 1 cl. S. Karmel	July 1 to Nov. 8, 1918.
Yeo. (F.) 3 cl. E. P. Blanchard	From Sept. 20, 1918.
Yeo. 3 cl. W. E. Brown	Apr. 17, 1917, to Apr. 19, 1918.
Yeo. 3 cl. R. M. Perry	From Feb. 23, 1918.
Sea. 2 cl. W. L. Bean	June 12 to Sept. 16, 1918.
M. Att. 3 cl. D. H. Broden	From Sept. 3, 1918.
M. Att. 3 cl. P. F. Hill	From Mar. 9, 1918.
M. Att. 3 cl. P M. Quander	From June 19, 1918.
M Att. 3 cl. G. Washington	Apr. 1 to Aug. 5, 1918.
Lds. for Yeo. J. B. Miller	May 28, 1917, to July 11, 1918.

SPECIAL BOARD ON NAVAL ORDNANCE.

Rear Admiral R. R. Ingersoll, U. S. Navy (ret.)	From July 9, 1917.
Rear Admiral S. A. Staunton, U. S. Navy (ret.)	From Oct. 10, 1918.
Commodore S. J. Brown (Math.), U. S. Navy (ret.)	Entire period.
Clerk T. M. Thorne	June 25, 1917, to May 25, 1918.

ENLISTED PERSONNEL.

Ch. Yeo. (F.) M. E. Tippett	From May 28, 1917.
Yeo. (F.) 2 cl. F. E. Nelson	From Sept. 24, 1918.
Yeo. 1 cl. H. J. Shea	From July 25, 1918, to Nov. 8, 1918.
Yeo. 1 cl. H. S. Vandiver	From Aug. 9, 1918.

AVIATION ORDNANCE SECTION.

Lt. Comdr. A. J. Stone, U. S. N. R. F	From Sept. 29, 1917.
Comdr. A. C. Stott, U. S. N	From Sept. 3, 1918.
Lt. Comdr. A. M. Cohen, U. S. N	June 21 to July 15, 1918.
Capt. C. G. More, R. A. F	May 21 to Oct. 11, 1918.
Maj. H. R. Raikes, R. A. F	From July 19, 1918.
Lt. A. J. Ditman, U. S. N. R. F	From Feb. 6, 1918.
Lt. H. P. Claussen, U. S. N. R. F	Sept. 17, 1917 to Dec. 11, 1917, and from Oct. 15, 1918.
Lt. (j g.) A. H. Boettcher, U. S. N. R .F	From Oct. 1, 1917.
Lt, (j. g.) H. B. Shepard, U. S. N. R. F	From Oct. 29, 1917.

Lt. (j. g.) J. M. Rutherford, U. S. N. R. F	From Aug. 31, 1918.
Lt. (j. g.) E. F. Gilbert, U. S. N. R. F	From Mar. 25, 1918.
Lt. (j. g.) E. H. Barry, U. S. N. R. F	From Oct. 29. 1917.
Lt. (j. g.) T. H. Sheridan, U. S. N. R. F	From Oct. 28, 1918.
Ensign R. Bowman, U. S. N. R. F	From Mar. 14, 1918.
Ensign F. Burns, U. S. N. R. F	From Oct. 28, 1918.
Marine Gunner F. A. Dorner, jr	From June 3, 1918.
Ensign W. J. Farthing, U. S. N. R. F	From Feb. 20, 1918.
Ensign L. B. Frieze, U. S. N. R. F	From Sept. 23, 1918.
Ensign C. H. Hauber, U. S. N. R. F	Do.
Ensign T. O. Hills, U. S. N. R. F	From Oct. 2, 1918.
Ensign W. E. Lundgren, U. S. N. R. F	From Oct. 28, 1918.
Ensign D. G. Morrison, U. S. N. R. F	From Oct. 28 to Nov. 4, 1918.
Ensign H. C. Murphy, U. S. N. R. F	From Apr. 8, 1918.
Ensign W. A. O'Brien, U. S. N. R. F	From July 7, 1918.
Ensign H. C. Parker, U. S. N. R. F	From Jan. 15, 1918.
Ensign E. M. Radway, U. S. N. R. F	From Aug. 14, 1918.
Ensign C. A. Singer, jr., U. S. N. R. F	From Aug. 21, 1918.
Ensign A. E. Turner, U. S. N. R. F	From Sept. 23, 1918.
Ensign L. Van Dam, U. S. N. R. F	From June 3, 1918.
Ensign L. G. Young, U. S. N. R. F	From Aug. 28, 1918.

ENLISTED PERSONNEL.

Yeo. (F.) 2 cl. M. E. Brady	From Oct. 3, 1918.
Yeo. (F.) 2 cl. N. Davenport	From Oct. 2, 1918.
Yeo. (F.) 2 cl. F. Momberger	Do.
Yeo. (F.) 3 cl. L. Phillips	From Oct. 31, 1918.
Chief Quartermaster D. D. Barnes	Aug. 10 to Sept. 26, 1918.
Chief Quartermaster C. H. Hauber	Aug. 26 to Sept. 22, 1918.
Chief Quartermaster L. W. Rockwell	Feb. 5 to May 8, 1918.
Chief Quartermaster A. E. Turner	Sept. 10 to Sept. 22, 1918.
Chief Yeoman J. J. McCarthy	From Apr. 4, 1918.
Chief Yeoman J. H. McKee	June 14 to Oct. 28, 1918
Chief Yeoman W. H. Smith	From July 12, 1918.
Chief Yeoman R. Warren	From Mar. 25, 1918.
Chief Storekeeper R. S. Kampmann	From Oct. 15, 1918.
Mach. Mate 1 cl. L. B. Frieze	Aug. 10 to Sept. 22, 1918.
Yeo. 1 cl. D. H. Moore	Aug. 12 to Nov. 1, 1918.
Yeo. 1 cl. K. Stecher	From May 16, 1918.
Yeo. 1 cl. J. J. Williams	June 25 to Nov. 1, 1918.
Gunner's Mate 2 cl. R. W. Conway	From June 3, 1918.
Mach. Mate 2 cl. C. E. Billings	Aug. 9 to Sept. 11, 1918.
Appr. Sea. F. W. Truex	From Aug. 19, 1918.

DESIGN SECTION.

Lt. Comdr. G. L. Smith, U. S. Navy (ret.)	From June 5, 1918.
Chief Draftsman G. A. Chadwick	From Sept. 24, 1918.
Draftsman Chargeman J. T. Humphreys	From Dec. 21, 1917.
Draftsman Chargeman R. R. Bright	Entire period.
Mathematician A. S. Hawkesworth	From Dec. 12, 1917.
Technical Assistant D. Troubtschaninoff	July 15 to Sept. 21, 1918.
Draftsman H. J. Biondi	From Dec. 21, 1917.

Draftsman C. R. Burr	Entire period.
Draftsman L. L. Cox	Sept. 15 to Dec. 12, 1917.
Draftsman P. F. Eroh	Sept. 24 to Oct. 5, 1917.
Draftsman G. A. Degenhardt	From June 30, 1917.
Draftsman P. H. Girouard	From Dec. 21, 1917.
Draftsman G. E. Eckendorf	Dec. 21, 1917, to Apr. 6, 1918.
Draftsman A. L. Jenkins	From Nov. 6, 1917.
Draftsman J. H. Lenden	From Oct. 15, 1917.
Draftsman H. Levine	Aug. 27, 1917, to Feb. 4, 1918.
Draftsman L. F. Lyke	From Sept. 18, 1917.
Draftsman J. M. May	From Sept. 4, 1917.
Draftsman John Miller, jr	From Aug. 30, 1917.
Draftsman W. E. Patrick, jr	From June 28, 1917.
Draftsman Joel Powers	Sept. 12, 1917, to Jan. 15, 1918.
Draftsman A. B. Pastor	Oct. 15 to Oct. 27, 1917.
Draftsman Edward C. Pyne	From May 1, 1918.
Draftsman C. G. Schmid	From Oct. 6, 1917.
Draftsman B. H. Slocum	From Oct. 1, 1917.
Draftsman C. D. Smalling	Do.
Draftsman A. Solomon	From Dec. 1, 1917.
Draftsman J. M. Walter	From Aug. 13, 1917.
Draftsman C. F. Weller	Entire period.
Draftsman H. G. Williams	June 11, 1917, to Feb. 19, 1918.
Messenger A. Prender	From July 14, 1918.

ENLISTED PERSONNEL.

Yeo. (F.) 1 cl. M. L. Duckett	From Aug. 2, 1918.
Yeo. (F.) 1 cl. H. F. Springfield	July 23 to Aug. 2, 1918.
Yeo. (F.) 3 cl. L. A. DeLaPointe	From Sept. 5, 1918.
Yeo. 1 cl. A. B. Hall	From May 16, 1917.
Yeo. 1 cl. G. W. Schmucker	From Oct. 3, 1917.
Yeo. 2 cl. E. L. Bailey	June 13, 1918, to Sept. 23, 1918.
Electrician (R.) 3 cl. F. A. Pierce	From Oct. 28, 1918.
Sea. 2 cl. A. H. Wagner	From Aug. 10, 1917.

EXPERIMENTAL SECTION.

Lt. Comdr. T. S. Wilkinson, jr., U. S. Navy	Entire period.
Lt. Comdr. J. E. Coates, R. N. V. R	From Aug. 23, 1918.
Lt. E. G. F. R. du Mazuel, U. S. N. R. F	From Sept. 24, 1917.
Lt. (j. g.) G. Blair, U. S. N. R F	Do.
Lt. (j. g.) B. W. Grimes, U. S. N. R. F	From Nov. 6, 1917.
Lt. (j. g.) H. H. Armstrong, U. S. N. R F	From Apr. 4, 1918.
Ensign (T.) R. G. Berger, U. S. Navy	From Oct. 29, 1918.
Clerk A. F. C. Sommerwerck, jr	Entire period.

ENLISTED PERSONNEL.

Ch. Yeo. (F.) F. L. Farrell	From Apr. 9, 1917.
Yeo. (F.) 3 cl. H. C. Lawrence	July 2, 1917, to Apr. 6, 1918.
Lds. for Yeo. (F.) L. B. Jones	From Sept. 24, to Oct. 31, 1918.
Ch. Mach. Mate F. B. Doane	Sept. 3 to Oct. 8, 1918.

FIRE CONTROL SECTION.

Lt. Comdr. F. C. Martin, U. S. Navy..........Until Aug. 20, 1917.
Comdr. W. R. Van Auken, U. S. Navy.........April 21, 1917, to Oct. 17, 1918.
Comdr. W. R. Furlong, U. S. Navy...........From Sept. 28, 1918.
Comdr. H. A. Orr, U. S. Navy...............From July 19, 1918.
Lt. Comdr. A. A. Michelson, U. S. N. R. F.....From June 29, 1918.
Lt. H. C. Mittendorf, U S. N. R. F............From Mar. 11, 1918.
Lt. (j. g.) J. J. Lamberty, U. S. N. R. F......From June 7, 1918.
Ensign F. L. Mason, U. S. N. R. F............From June 4, 1918.
Technical Assistant Lawrence Radford.......From July 18, 1917.

ENLISTED PERSONNEL.

Ch. Yeo. (F.) B. Tausig.....................From June 17, 1918.
Yeo. (F.) 1 cl. E. V. Edler...................From Apr. 25, 1918.
Yeo. (F.) 2 cl. V. K. Titus...................From Sept. 10, 1918.
Yeo. (F.) 3 cl. E. N. Clements...............From Oct. 4, 1918.
Yeo. (F.) 3 cl. I. K. Davison................From Oct. 14, 1918.
Yeo. (F.) 3 cl. D. Holmes...................From Sept. 24, 1918.
Yeo. (F.) 3 cl. S. G. Prentiss................May 8, 1917, to May 25, 1917.
Yeo. (F.) 3 cl. M. E. Shears................From Oct. 24, 1917, to June 7, 1918.
Lds. for Yeo. (F.) G. M. Hoffman...........From Sept. 18, 1918.
Ch. Yeo. E. J. Cunningham.................From June 20, 1917, to April 29, 1918.
Ch. Yeo. L. T. Gilroy......................From Dec. 3, 1917.
Yeo. 2 cl. E. M. Hughes....................From May 14, 1917.
Yeo. 2 cl. F. J. Mitchell....................Apr. 8 to Sept. 27, 1918.

GUN SECTION.

Lieut. Comdr. N. W. Pickering, U. S. Navy....Entire period.
Lieutenant W. I. Howland, U. S. N. R. F.....From Jan. 3, 1918.
Lieutenant H. W. Brooks, U. S. N. R. F......From Aug. 29, 1918.
Lieutenant A. G. Kessler, U. S. N. R. F......From July 1, 1917.
Lt. (j. g.) L. A. Saladé, U. S. N. R. F.........From Oct. 15, 1917.
Lt. (j. g.) W. C. Darling, U. S. N. R. F.......From Dec. 28, 1917.
Ensign M. H. Barnes, U. S. N. R. F...........Mar. 12, 1918, to Oct. 20, 1918.
Clerk C. E. Costlow.........................Entire period.
Clerk M. L. Friedman....................... Do.
Clerk Ethel Wood..........................From Sept. 18, 1917.

ENLISTED PERSONNEL.

Yeo. (F.) 2 cl. G. G. Smith..................From Oct. 14, 1918.
Yeo. (F.) 2 cl. M. L. Wellner...............From Aug. 19, 1918.
Yeo. (F.) 3 cl. G. Blasdel...................From Oct. 29, 1918.
Yeo. (F.) 3 cl. M. F. Hull...................From Apr. 24, 1917, to Jan. 5, 1918.
Yeo. (F.) 3 cl. M. E. Reed..................From Sept. 17, 1918.
Yeo. (F.) 3 cl. H. A. Snyder...............Aug. 16 to Sept. 18, 1918.
Yeo. 1 cl. D. V. Payne......................From Oct. 29, 1918.

GUN MOUNT SECTION.

Lt. Comdr. S. C. Rowan, U. S. Navy	Until Apr. 8, 1918.
Comdr. F. L. Reichmuth, U. S. Navy	From Mar. 15, 1918.
Lt. Comdr. W. R. Raudenbush, U. S. N. R. F.	From July 11, 1917.
Lt. (j. g.) E. D. Beals, U. S. N. R. F.	From Feb. 1, 1918.
Lt. (j. g.) J. M. Evans, U. S. N. R. F.	From Dec. 17, 1917.
Lt. (j. g.) P. E. Hurd, U. S. N. R. F.	From Apr. 23, 1918.
Ensign F. B. Tallman, U. S. N. R. F.	From May 16, 1918.
Stenographer M. C. LaMothe	From Sept. 15, 1917.
Stenographer E. M. Anderson	From Mar. 1, 1918.

ENLISTED PERSONNEL.

Yeo. (F.) 1 cl. C. P. Ridgely	From June 21, 1917.
Yeo. (F.) 2 cl. E. Hayes	From Sept. 24, 1918.
Yeo. (F.) 2 cl. W. P. Jackson	Do.
Yeo. (F.) 2 cl. B. E. Kummer	From Jan. 21, 1918.
Yeo. (F.) 3 cl. M. C. Thompson	From Sept. 24, 1918.
Yeo. 2 cl. W. F. Reagan	From Mar. 28, 1918.

MINES AND NETS SECTION.

Comdr. S. P. Fullinwider, U. S. Navy (ret.)	Entire period.
Capt. E. T. Fitzgerald, U. S. N. R. F.	From Oct. 10, 1918.
Comdr. O. G. Murfin, U. S. Navy	July 12, to Nov. 6, 1917.
Lt. Comdr. J. A. Schofield, U. S. N. R. F.	From June 16, 1917.
Lt. Comdr. H. Isherwood, R. N. V. R.	Oct. 8, 1917, to May 17, 1918.
Lt. Comdr. H. O. Mock, R. N. V. R.	May 10, to Sept. 19, 1917.
Lt. Comdr. C. H. Wright, U. S. Navy	From Nov. 27, 1917.
Lt. Comdr. W. A. Corley, U. S. Navy	From Nov. 22, 1917.
Lt. Comdr. H. E. Fischer	From Nov. 10, 1917.
Lt. R. H. DeSalis, R. N.	Sept. 1 to Dec. 19, 1917.
Lt. S. W. Cook, U. S. N. R. F.	From Oct. 31, 1917.
Lt. L. W. McKeehan, U. S. N. R. F.	From Feb. 11, 1918.
Lt. (j. g.) A. F. Dahlstrom, U. S. N. R. F.	Nov. 27 to Dec. 6, 1917.
Lt. (j. g.) H. G. Mosler, U. S. N. R. F.	From May 14, 1918.
Lt. (j. g.) M. M. Sibbley, U. S. N. R. F.	Nov. 24 to Dec. 6, 1917.
Lt. (j. g.) O. W. Boston, U. S. N. R. F.	From Oct. 19, 1917.
Lt. (j. g.) W. Y. Duncan, U. S. N. R. F.	From Nov. 7, 1917.
Lt. (j. g.) J. J. Chew, U. S. N. R. F.	From May 27, 1918.
Lt. (j. g.) C. W. Hall, U. S. N. R. F.	From May 10, 1918.
Lt. (j. g.) G. B. Massey, U. S. N. R. F.	Nov. 26 to Dec. 5, 1917.
Lt. (j. g.) A. J. Love, U. S. N. R. F.	Nov. 19, 1917, to Feb. 7, 1918.
Ensign W. C. Manly, U. S. N. R. F.	From Oct 26, 1918.
Ensign W. H. Stillwell, U. S. N. R. F.	Mar. 2 to July 5, 1918.
Ensign S. T. Brown, U. S. N. R. F.	Dec. 17, 1917, to Apr. 5, 1918.
Ensign J. J. Munns, U. S. N. R. F.	Sept. 4 to Oct. 29, 1917.
Ensign F. D. Stovell, U. S. N. R. F.	Nov. 23 to Dec. 6, 1917.
Machinist D. A. Warriner, U. S. N. R. F.	Nov. 27 to Dec. 6, 1917.
Technical Assistant Chester T. Minkler	May 21, 1917, to Mar. 19, 1918.
Clerk E. J. Smith	From Nov. 12, 1917.
Clerk G. Tinsley	From Nov. 20, 1917.
Clerk Stella Moloney	Nov. 15, 1917, to Sept. 30, 1918.

ENLISTED PERSONNEL.

Ch. Yeo. (F.) M. E. Creveling	From May 17, 1917.
Yeo. (F.) 1 cl. I. R. Balter	From Aug. 27, 1918.
Yeo. (F.) 1 cl. M. T. Killilea	Apr. 2 to Aug. 28, 1918.
Yeo. (F.) 2 cl. I. E. Miner	Aug. 9 to Sept. 18, 1918.
Yeo. (F.) 3 cl. S. O. Berry	From Jan. 23, 1918.
Yeo. (F.) 3 cl. M. E. Davis	Apr. 6 to Sept. 30, 1918.
Yeo. (F.) 3 cl. A. Thomson	Apr. 17 to June 1, 1917.
Lds. (F.) for Yeo. M. E. Farnsworth	From Oct. 2, 1918.
Lds. (F.) for Yeo. Z. A. Harmon	From Oct. 14, 1918.
Lds. (F.) for Yeo. J. L. Markland	Do.
Lds. (F.) for Yeo. O. E. Newman	From Sept. 18, 1918.
Lds. (F.) for Yeo. M. F. Westergaard	From Oct. 29, 1918.
Yeo. 1 cl. W. M. Tuttle	From Aug. 9, 1918.
Yeo. 3 cl. W. C. Bowen	From Oct. 28, 1918.
Yeo. 3 cl. C. L. Flynn	Do.
Yeo. 3 cl. J. J. Sullivan	Do.
Sea. 2 cl. W. E. Loring	Do.
Sea. 2 cl. D. F. O'Connor	Do.
Sea. 2 cl. J. C. Parker	From Oct. 30, 1918.
Lds. for Yeo. C. L. Stillman	From Oct. 31, 1918.

NITRATES AND ACIDS SECTION.

Lt. Comdr. Donald Riley, U. S. N. R. F	From Nov. 9, 1917.
Lt. R. E. McConnell, U. S. N. R. F	From Apr. 15, 1918.
Lt. J. Kendall, U. S. N. R. F	From Sept. 5, 1917.
Lt. P. DeAngelis, U. S. N. R. F	From July 5, 1918.
Lt. (j. g.) P. L. McCulloch, U. S. N. R. F	From Sept. 9, 1918.
Lt. (j. g.) C. V. Craig, U. S. N. R. F	From Sept. 26, 1918.
Lt. (j. g.) F. W. Foote, U. S. N. R. F	From Mar. 29, 1918.
Ensign H. T. Corio, U. S. N. R. F	From Aug. 5, 1918.
Ensign H. L. Harrison, U. S. N. R. F	From Aug. 6, 1918.
Ensign A. H. Burroughs, jr., U. S. N. R. F	From Aug. 19, 1918.
Ensign R. U. Wood, U. S. N. R. F	From Aug. 27, 1918.
Ensign C. M. Briggs, U. S. N. R. F	From Aug. 31, 1918.
Ensign H. B. Heyn, U. S. N. R. F	From Nov. 5, 1918.
Clerk Elsa V. Mentzer	From Apr. 16, 1918.
Clerk George Gilbert	Until Jan. 31, 1918.
Master Mechanic W. E. Hayes	May 14, 1917, to Feb. 20, 1918.

ENLISTED PERSONNEL.

Cr. Mach. Mate H. B. Heyn	June 14, 1918, to Nov. 4, 1918.
Yeo. 1 cl. S. L. Zuckert	From Apr. 1, 1918.

ARMOR AND PROJECTILE SECTION.

Comdr. R. S. Holmes, U. S. Navy	Until Oct. 10, 1918.
Comdr. Logan Cresap, U. S. Navy	From Sept. 11, 1918.
Capt. F. H. Clark, U. S. Navy	Until Mar. 2, 1918.
Lt. (j. g.) W. J. Keating, U. S. N. R. F	From Oct. 14, 1917.
Ensign R. G. Farrell, U. S. N. R F	From July 8, 1918.
Ensign M. J. Rosencrantz, U. S. N. R. F	From Aug. 10, 1918.
Clerk W. T. Baker	Entire period.
Clerk C. G. Chandler	From Sept. 17, 1917.

ENLISTED PERSONNEL.

Yeo. (F.) 3 cl. O. V. Watters.............From Sept. 19, 1918.

POWDER AND FUSE SECTION.

Lt. Comdr. G. L. Caskey, U. S. Navy.........Until Feb. 3, 1918.
Comdr. W. W. Bradley, U. S. Navy..........From Jan. 8, 1918.
Lt. Comdr. R. L. Lowman, U. S. N. R. F......From Sept. 24, 1917.
Lieut. F. L. Rupp, U. S. N. R. F..............From June 30, 1917.
Lieut. (j.. g.) M. F. Brandt, U. S. N. R. F....From May 1, 1918.
Ensign H. F. Flory, U. S. N. R. F............Jan. 8 to May 27, 1918.
Ensign W. T. McGeorge, U. S. N. R. F........From June 12, 1918.
Ensign R. H. Oller, U. S. N. R. F............From July 15, 1918.
Ensign C. L. McCune, U. S. Navy............June 12 to Nov. 4, 1918.
Clerk L. R. Barry..........................Apr. 9 to Apr. 14, 1917.
Clerk C. H. Birmingham, jr..................Until Aug. 24, 1917.
Clerk T. W. Casey..........................Entire period.
Clerk L. J. McCarthy........................Until Mar. 12, 1918.
Clerk D. Stewart...........................Entire period.
Clerk C. F. Bain............................June 25, 1917, to Aug. 15, 1917.

ENLISTED PERSONNEL.

Yeo. (F.) 1 cl. E. M. Gulembo...............From July 24, 1918.
Yeo. (F.) 3 cl. P. Coursey..................From Sept. 23, 1918.
Yeo. (F.) 3 cl. M. Lipscomb.................From Sept. 18, 1918.
Yeo. (F.) A. B. Moore.......................From Sept. 24, 1918.
Yeo. (F.) V. E. Vincent.....................From Oct. 2, 1918.
Lds. (F.) for Yeo. M. Ernest.................From Nov. 11, 1918.
Ch. Mach. Mate B. Kelley....................Sept. 19 to Nov. 6, 1918.
Ch. Mach. Mate A. M. Loew...................From Sept. 30, 1918.
Ch. Yeo. H. O'C. Cross......................From April 18, 1918.
Ch. Yeo. L. J. McCarthy.....................From May 1, 1918.
Ch. Yeo. W. D. Rourke.......................From June 19, 1918.
Ch. Yeo. C. C. Stewart......................From June 14, 1917.
Ch. Yeo. E. J. Zukor........................From June 24, 1918.
Yeo. 2 cl. H. R. O'Conor.....................From July 31, 1918.

SUPPLY SECTION.

Lt. Comdr. W. T. Lightle, U. S. Navy........Until Jan. 10, 1918.
Comdr. W. S. McClintic, U. S. Navy..........From Jan. 2, 1918.
Comdr. R. B. B. Brummett, N. N. V...........Until April 15, 1917.
Lt. Comdr. J. H. Conditt, U. S. Navy (ret.)...Entire period.
Lt. Comdr. C. M. Lynch, U. S. Navy (ret.)....From Sept. 11, 1917.
Capt. C. W. Cairnes, U. S. C. G. (ret.)........From May 5, 1917.
Capt. W. K. Scammell, U. S. C. G............From Dec. 10, 1917.
Lt. M. M. Fenner, U. S. N. R. F..............From Jan. 1, 1918.
Lt. (j. g.) W. S. Doxey, U. S. N. R. F.........From Oct. 24, 1917.
Lt. (j. g.) T. J. Reidy, U. S. N. R. F..........From Mar. 20, 1918.
Ensign L. H. Elliott, U. S. N. R. F...........From Oct. 7, 1918.
Clerk S. W. Crosthwait......................Until Aug. 7, 1918.
Clerk Michael Harris.........................Until July 30, 1918.
Clerk Mary H. Higgins.......................From May 4, 1918.
Clerk Ella C. Leech..........................From Nov. 16, 1917.
Clerk N. J. McCool...........................From Nov. 27, 1917.
Clerk George H. Powell.......................Until Aug. 18, 1917.
Clerk E. W. Ave Lallemant....................Until Aug. 23, 1917.
Clerk K. M. O'Brien..........................From Aug. 1, 1918.

ENLISTED PERSONNEL.

Yeo. (F.) 2 cl. N. K. Anderson	From Oct. 14, 1918.
Yeo. (F.) 2 cl. E. R. Claxton	From May 9, 1917.
Yeo. (F.) 2 cl. L. Fugitt	From Dec. 10, 1917.
Yeo. (F.) 2 cl. E. C. Leech	Apr. 9 to Nov. 15, 1917.
Yeo. (F.) 2 cl. G. L. Ruppert	From May 1, 1917.
Yeo. (F.) 2 cl. M. A. Ruppert	From Apr. 14, 1917.
Yeo. (F.) 3 cl. Agnes Ackerman	Nov. 1, 1917, to Nov. 27, 1917.
Yeo. (F.) 3 cl. C. Babler	From Sept. 24, 1918.
Yeo. (F.) 3 cl. E. L. Dowling	From July 22, 1918.
Yeo. (F.) 3 cl. Augusta L. Hamilton	Aug. 15, 1917, to Oct. 3, 1917.
Yeo. (F.) 3 cl. M. H. Higgins	Apr. 19, 1917, to May 3, 1918.
Yeo. (F.) 3 cl. M. Huebl	From Sept. 6, 1918.
Yeo. (F.) 3 cl. M. R. Turner	May 13 to Oct. 25, 1917.
Yeo. 1 cl. S. W. Crosthwait	From Aug. 8, 1918.
Yeo. 1 cl. T. J. Heaney	Oct. 15, 1917, to Sept. 16, 1918.
Yeo. 1 cl. R. A. Vail	Oct. 4, 1917, to Jan. 2, 1918.
Yeo. 1 cl. H. C. T. Welsh, jr	Oct. 3, 1917, to June 3, 1918.
Yeo. 2 cl. E. P. Lambert	July 2 to July 10, 1918.
Yeo. 2 cl. S. J. Miller	Oct. 3, 1917, to Apr. 9, 1918.
Yeo. 2 cl. H. A. Willard	From July 12, 1918.
Yeo. 3 cl. J. L. Donnelly	From June 26, 1918.
Seaman L. D. Blair	From Dec. 27, 1917, to Feb. 15, 1918.

TORPEDO SECTION.

Commander J. V. Ogan, U. S. Navy	Until Apr. 12, 1918.
Commander G. B. Wright, U. S. Navy	From Feb. 16, 1918.
Lt. (j. g.) T. A. Stetson, U. S. N. R. F	July 11 to Aug. 15, 1918.
Lt. (j. g.) J. A. Flint, U. S. N. R. F	From Feb. 16, 1918.
Ensign G. M. Macheca, U. S. N. R. F	From July 21, 1918.
Clerk E. L. Bennett	Entire period.
Clerk D. W. Brown	From Sept. 3, 1918.

ENLISTED PERSONNEL.

Ch. Yeo. (F.) V. B. Jones	From June 20, 1917.
Yeo (F.) 3 cl. R. Hunter	April 9, 1917, to June 4, 1917.

TORPEDO STATION, ALEXANDRIA, VA.

PERSONNEL TEMPORARILY IN BUREAU.

Capt. W. S. Miller, U .S. Navy	From Aug. 30, 1918.
Lieut. G. S. Baldwin (S. C.) U. S. Navy	From Sept. 23, 1918.
Lieut. G. E. Brown (S. C.) U. S. N. R. F	From Aug. 15, 1918, to Sept. 30, 1918.
Master Mechanic J. W. McConnell	From Sept. 18, 1918.

ENLISTED PERSONNEL.

Yeo. (F.) 2 cl. R. M. Ruhlman	From Oct. 10, 1918.
Yeo. (F.) 3 cl. C. M. Harney	Do.
Yeo. (F.) 3 cl. K. E. McCarthy	From Sept. 17, 1918.
Lds. (F.) for Yeo. L. Hartsfield	From Sept. 18, 1918.

Turret Mount Section.

Lt. Comdr. W. R. Van Auken, U. S. Navy----Until Apr. 20, 1917.
Lt. Comdr. L. B. Bye, U. S. Navy------------From Apr. 21, 1917.
Ensign L. E. Brown, U. S. N. R. F-----------From Aug. 6, 1918.
Ensign C. L. McCrea, U. S. N. R. F----------From Nov. 21, 1917.
Clerk Benj. Morris--------------------------Entire period.

ENLISTED PERSONNEL.

Yeo. (F.) 1 cl. M. Kolb---------------------From Sept. 5, 1918.
Yeo. (F.) 3 cl. E. E. Layfield--------------From Sept. 24, 1918.
Yeo. (F.) 3 cl. E. A. Smith-----------------From Oct. 4, 1918.
Lds. (F.) for Yeo. H. M. Fox----------------From Sept. 18, 1918.
Yeo. 1 cl. D. Schuham-----------------------Apr. 23 to Sept. 23, 1918.
Yeo. (F.) 3 cl. A. G. Steele----------------From Oct. 10, 1918.

General Inspector of Ordnance.

Commander A. L. Norton, U. S. Navy (ret.)---Entire period.

ENLISTED PERSONNEL.

Ch. Yeo. (F.) A. L. Burton------------------From May 10, 1917.
Ch. Yeo. (F.) M. E. Walker------------------From June 11, 1917.
Lds. (F.) for Yeo. A. M. Bell---------------From Oct. 4, 1918.
Fireman 1 cl. C. M. Carr--------------------Jan. 2 to June 15, 1918.

Patent Section.

Technical Assistant P. A. Blair-------------From July 18, 1917.
Ensign R. M. Norris, U. S. N. R. F----------From May 12, 1918.

ENLISTED PERSONNEL.

Yeo. (F.) 1 cl. M. T. Hogan-----------------From Aug. 28, 1918.
Yeo. (F.) 2 cl. G. A. Smith-----------------From Aug. 26, 1918.
Ch. Mach. Mate E. O. Crocker----------------From July 15, 1918.
Ch. Mach. Mate T. C. Lindsey (later ensign)- Do.
Ch. Mach. Mate R. M. Norris-----------------Dec. 17, 1917, to May 11, 1918.

Selective Service Section.

Lt. Comdr. F. O. Branch, U. S. Navy (ret.)---From Dec. 14, 1917.
Lt. (j. g.) C. B. Rugg, U. S. N. R. F-------From Jan. 4, 1918.
Ensign F. S. Moulton, U. S. N. R. F---------From Nov. 5, 1918.
Clerk Cora E. Davies------------------------From Apr. 17, 1918.
Clerk Laura Johnson-------------------------From Dec. 26, 1917.
Clerk James H. Roberts----------------------From May 6, 1918.

ENLISTED PERSONNEL.

Yeo. (F.) 1 cl. Rena Ogle-------------------From Jan. 14, 1918.
Yeo. (F.) 2 cl. R. A. Kelley----------------From Sept. 12, 1918.
Yeo. 2 cl. H. W. Wrede----------------------Apr. 12, 1918, to Sept. 23, 1918.

LABOR SECTION.

Lt. G. H. Johnson, U. S. N. R. F.............From Aug. 21, 1918.
Lt. (j. g.) B. B. Weiss, U. S. N. R. F.........From June 12, 1918.

PRIORITIES SECTION.

Rear Admiral N. E. Mason, U. S. N. (ret.)....From June 2, 1917.
Lt. J. M. Blankenship, U. S. N. (ret.).........From Sept. 3, 1917.
Lt. (j. g.) C. M. O'Boyle, U. S. N. R. F.......Oct. 10, 1917, to Mar. 24, 1918.

SHIP PROTECTION SECTION.

Rear Admiral A. R. Couden, U. S. N. (ret.)...From Sept. 18, 1917.

COST BOARD SECTION.

Commander J. H. Moore, U. S. N. (ret.)......From Sept. 8, 1917.

ENLISTED PERSONNEL.

Yeo. (F.) 2 cl. A. R. Magruder...............From June 11, 1917.

BUILDINGS AND GROUNDS SECTION.

Lt. W. W. Little, U. S. N. R. F...............From July 25, 1918.
Lt. (j. g.) W. S. Schneider, U. S. N. R. F.....From Sept. 4, 1918.
Ensign J. B. Kingsley, U. S. N. R. F..........From Sept. 16, 1918.

ENLISTED PERSONNEL.

Yeo. (F.) 3 cl. D. E. Packman...............From Oct. 31, 1918.
Lds. (F.) for Yeo. M. C. Morlan.............From Oct. 16, 1918.

APPENDIX III.

DUTIES OF SECTIONS OF THE BUREAU.

The Bureau of Ordnance is divided into six groups:

(a) Executive and administrative.
(b) Technical.
(c) Inventions, research, and trials.
(d) Civil.
(e) Industrial.
(f) Yards, plants, and stations.

These six are further subdivided into 27 sections. Unless otherwise noted, a section assigned "cognizance" or "charge" of any item or class of material is understood to be responsible for the following:

(a) Design and preparation of specifications.
(b) Manufacture, purchase, and tests.
(c) Preparation of ordnance pamphlets or other descriptive matter.
(d) Installation and report on performance.
(e) Preservation and repair.
(f) Final disposition.

DUTIES OF GUN SECTION.

This section has cognizance over:

(a) All naval guns except small arms.
(b) Depth charge Y guns and their arbors.
(c) Gas ejector apparatus attached to guns.
(d) Construction and expansion of all naval gun and gun forging plants.
(e) Ordnance post graduate class.

DUTIES OF TURRET-MOUNT SECTION.

This section has cognizance over:

(a) All ordnance turret work, except guns, armor, fire-control apparatus, telescopes, and periscopes.
(b) Gas ejector system in turrets but not attached to guns.
(c) Turret dotters.
(d) Railway and tractor batteries.
(e) Procurement and distribution of confidential and nonconfidential information pertaining to the naval service, with particular reference to ordnance matters.
(f) Procurement, compilation, indexing, and issue of historical information pertaining to the naval service with particular reference to ordnance matters.

DUTIES OF POWDER, EXPLOSIVES, AND FUSE SECTION.

This section has cognizance over:

(*a*) Manufacture and procurement of gun powders, and other explosive propellants, together with their containers.

(*b*) Manufacture and procurement of explosives used with mines and torpedoes. (Loading of mines and torpedoes is under the Mine and Torpedo Sections.)

(*c*) Acceptance tests of powder, fuses, primers, and other explosives.

(*d*) Work at naval ammunition depots.

(*e*) Ammunition hoists outside turrets.

(*f*) Records of powders and other explosives.

(*g*) Construction and expansion of Naval Powder Factory.

DUTIES OF TORPEDO SECTION.

This section has cognizance over:

(*a*) Torpedoes, gyros and stands, war heads, and net cutters attached to torpedoes.

(*b*) Torpedo tubes and torpedo launching devices.

(*c*) Torpedo directors except telescopes and periscopes.

(*d*) Torpedo air compressors and separators, except on submarines.

(*e*) Torpedo testing barges when under the Bureau of Ordnance.

(*f*) Torpedo nets for ship protection.

(*g*) Matters pertaining to the expansion, construction, and operation of plants engaged in the production of torpedoes, torpedo tubes, and air compressors; including naval torpedo stations, Newport, R. I., Alexandria, Va., Keyport, Wash., and torpedo storehouses and repair stations at naval ammunition depots, naval stations, and bases.

DUTIES OF ARMOR AND PROJECTILE SECTION.

This section has cognizance over:

(*a*) Manufacture and procurement of armor and projectiles.

(*b*) Shipment of projectiles from points of manufacture to ammunition depots.

(*c*) Ballistic tests of armor and projectiles.

(*d*) Metallurgical questions not related to gun construction.

(*e*) Matters pertaining to the construction and equipment of the Naval Ordnance Plant, South Charleston, W. Va., with the exception of gun forgings made at that plant.

DUTIES OF SUPPLY SECTION.

This section has cognizance over:

(*a*) Preparation, issue, and correction of all ordnance allowance lists.

(*b*) Assembly, shipment, and issue of items on ordnance allowance lists not assigned to other sections.

(c) The assignment and issue of armament to tugs, patrol vessels, armed vessels of the War Department, Emergency Fleet Corporation, Merchant Marine, and all auxiliary vessels of the Naval Service.

(*d*) Issue of ammunition to all armed vessels.

(*e*) Issue of Y guns, depth charges and their accessories.

(*f*) Record of ships' movements and corrected addresses of vessels, shore stations, and naval bases.

(*g*) Loan of condemned ordnance material for patriotic exhibition purposes.

(*h*) Issue of ordnance material to coast guard, marine corps, naval militia, and educational institutions.

DUTIES OF FIRE-CONTROL SECTION.

This section has cognizance over:

(*a*) Manufacture and procurement of material used in connection with the fire-control systems of the Navy.

(*b*) Director firing systems.

(*c*) Optical repair plants ashore and afloat, together with the training of optical machinists.

(*d*) Navy Department representative on the optical glass and military instruments section of the War Industries Board.

(*e*) Matters pertaining to the expansion, construction, and operation of the Naval Gun Factory optical shop and optical shop annex, Rochester, N. Y., and other plants producing optical or fire-control material for the Bureau of Ordnance.

DUTIES OF GUN-MOUNT SECTION.

This section has cognizance over:

(*a*) Broadside and secondary battery mounts with sights, but not telescopes; also, howitzer mounts for use aboard ships.

(*b*) Small arms and accoutrements.

(*c*) Machine guns except for aircraft.

(*d*) Dotters except for turrets; loading machines and drill guns.

(*e*) Targets and target rafts.

DUTIES OF AVIATION ORDNANCE SECTION.

This section has cognizance over:

(*a*) All aircraft armament, including armor.

(*b*) Camera guns and other training devices for aircraft.

(*c*) Selection and training of gunner's mates for aviation ordnance duties at naval air stations.

(*d*) Bureau representatives at meetings of Joint Army and Navy Technical Board and Aircraft Production Board.

DUTIES OF MINES AND NET SECTION.

This section has cognizance over:

(*a*) Manufacture, procurement, and loading of naval mines, depth charges, and wrecking charges.

(*b*) Manufacture or procurement of defense nets—other than for use on board ship—and appliances used therewith.

(*c*) Manufacture or procurement of explosive charges used in connection with mine sweeping or paravane equipment.

DUTIES OF EXPERIMENTAL SECTION.

This section has cognizance over:

(*a*) Work in connection with trial or development of ordnance material or devices until such time as they are perfected, abandoned, or their quantity production decided upon.

(*b*) Gas warfare material.

DUTIES OF NITRATES AND ACIDS SECTION.

This section has cognizance over:

(a) Nitrogen fixation; the design, development, manufacture, and procurement; including processes, plant design, construction, and operation.

(b) Platinum; its procurement and distribution.

(c) Supervision of supply of raw materials to contractors engaged upon explosive work for the Bureau of Ordnance.

DUTIES OF SPECIAL BOARD ON NAVAL ORDNANCE.

This board has cognizance over:

(a) Initial research along original lines and make investigations of scientific problems related to ordnance and gunnery.

(b) Formal official tests, trials, and experimental work.

DUTIES OF DESIGN SECTION.

This section has cognizance over:

(a) Design and preparation of plans, drawings, and prints, in conjunction with the section having cognizance of ordnance material.

(b) Distribution of tracings, prints, and vandykes to ships and stations.

(c) Technical reference books and pamphlets.

DUTIES OF SHIP PROTECTION SECTION.

This section will act as the bureau's representative on all boards having for their purpose the protection, armament, and equipment of vessels of the merchant marine.

DUTIES OF COST BOARD SECTION.

This section shall have charge of ordnance details pertaining to cost accounting, plant orders, wage schedules, police protection, purchase of machinery, insurance, materials, and construction of buildings involving the expenditure of bureau appropriations by commercial firms operating on a cost plus or fixed profit basis in the production of ordnance material.

DUTIES OF PRIORITIES SECTION.

This section shall act as the bureau's representative on the War Industries Board, clearance committees of the Navy Department, and Council of National Defense, in the matter of procurement and determination of contract, manufacture, and distribution of priorities.

DUTIES OF BUILDINGS AND GROUNDS SECTION.

This section has cognizance over:

(a) Layout, construction, and development of plans for all buildings and grounds, wharves, slips, and piers under the cognizance and control of the Bureau of Ordnance.

(b) Examination of plans, drawings, blue prints, and proposals submitted by the Bureau of Yards and Docks that may require approval of the Bureau of Ordnance.

DUTIES OF CHIEF CLERK'S SECTION.

This section has cognizance over:

(*a*) All clerical force employed in the bureau.
(*b*) Requisitions for office furniture and supplies.
(*c*) Issue of pay checks to all persons attached to the bureau.
(*d*) Bureau's seal, messenger, and janitor service.
(*e*) Keys for all spaces assigned the bureau.

DUTIES OF FINANCE AND SPECIAL CONTRACT SECTION.

This section has cognizance over:

(*a*) Questions of contract law; interpretation of appropriation acts and statutory laws.
(*b*) Legal features concerning commandeering of property and material for Bureau of Ordnance.
(*c*) Preparation of priority requests.
(*d*) Proportionment of monthly allotments from bureau's appropriations.
(*e*) Data showing obligations, expenditures, credits, and balances under the several appropriations assigned to the Bureau of Ordnance.

DUTIES OF REQUISITION AND OPEN PURCHASE CONTRACT SECTION.

This section has cognizance over:

(*a*) Open purchase contracts and open purchase requisitions.
(*b*) Bids and proposals unless specifically assigned to another section.

DUTIES OF FILES AND RECORDS SECTION.

This section has cognizance over:

(*a*) The opening, numbering, recording, and routing of all incoming mail.
(*b*) The recording, numbering, and final release of all outgoing mail.
(*c*) Custody of all correspondence on file in the Bureau of Ordnance.

DUTIES OF MAILING SECTION.

This section has cognizance over:

(*a*) The collection and proper delivery of all mail within the bureau.
(*b*) Custody and issue under Supply Section of ordnance pamphlets.
(*c*) Final preparation of outgoing mail for delivery to Navy Department Post Office.

DUTIES OF INSPECTION SECTION.

This section has cognizance over:

(*a*) Establishment and maintenance of ordnance inspection districts throughout the United States.
(*b*) The physical and chemical inspection of materials in process of manufacture.
(*c*) Issue of inspection calls.

DUTIES OF PATENT SECTION.

This section has cognizance over:

(*a*) Matters relating to patents, patent rights, royalties, infringements, interferences, claims, and like questions relating to patent law.

(*b*) Preparation and prosecution of patent applications made by any person from whom the invention has been purchased by the United States.

DUTIES OF SELECTIVE-SERVICE SECTION.

This section has cognizance over:

(*a*) Matters relating to operation of selective-service regulations concerning persons employed by the Bureau of Ordnance, or at private plants performing work for the bureau.

(*b*) Requests for furlough and return to essential industrial pursuits of men in active military service.

(*c*) Emergency fleet exemptions and draft classifications.

(*d*) Bureau's representative in office of the Provost Marshal General of the Army.

DUTIES OF THE LABOR SECTION.

This section has cognizance over:

(*a*) Matters relating to the application and operation of policies, rulings, and decisions in questions directly pertaining to labor, compensation, and conditions of industrial employment as announced by the Navy Department.

(*b*) Investigation and, when directed, the arbitration and settlement of disputes between employer and employees connected with private plants performing work for the Bureau of Ordnance.

Appendix IV.

PERSONNEL OF PLANTS AND INSPECTION FORCE.

Officers on duty in the bureau's inspection force between Apr. 6, 1917, and Nov. 11, 1918.

Plant or district.	Officers.	On duty.
E. W. Bliss Co., Brooklyn, N. Y.	Commander F. L. Sawyer, U. S. Navy (ret.)	12 months.[1]
	Commander E P Svarz, U. S. Navy	10 months.
	Lieut. Comdr. J C Jennings, U. S. Navy	19 months.
	Lieut. P. K. Robottom, U S Navy	Do.
	Lieut. (j. g) Jack K Campbell, U. S. Navy	1 month.
	Lieut. (j. g) William J Creelman	6 months
	Gunner (T) Charles E. Avery, U. S. Navy	5 months.
	Gunner (T) C E. Heineman, U. S. Navy	19 months.
	Lieut. (T) (G.) Leroy Rodd, U S Navy	4 months.
	Lieut. Comdr. Howard D. Bode, U. S. Navy	Do.
	Ensign G. H. Bray, U. S. N. R. F.	1 month.
	Ensign Walter F. Hinckley, U. S. N. R. F.	Do.
	Lieut (j g) Daniel F. Mulvihill (M. C. D. S.)	16 months.
	Lieut. (T.) (G.) W. F. Schlegel, U. S. Navy	19 months.
	Lieut. Francis L. Shea, U S. Navy	11 months.
	Lieut. (T.) (G.) A S. Pearson, U. S. Navy	16 months.
	Gunner (T.) John L. Burns, U. S. Navy	Do.
	Lieut. Max M. Frucht, U. S. Navy	8 months.
	Lieut. (j. g.) Herbert A. Nevins, U. S. Navy	19 months.
	Ensign Jos. R. Williams, U. S. N. R. F.	2 months.
Sperry Gyroscope Co. & Ford Instrument Co., Brooklyn, N. Y.	Commander B B McCormick, U. S. Navy (ret.)	12 months.[2]
	Lieut. Lee H. Harris, U. S. N R. F.	6 months.
	Ensign Frank W. Toppan, U S. Navy (ret.)	12 months.
	Lieut. (j g.) A. E. Bentfeld (T.)	Do.
	Lieut. (j. g.) Samuel G. Way, U. S. N. R. F.	5 months.
	Lieut. S B. Austin, U. S. N. R. F.	4 months.
	Lieut. N. L. Stevens, U. S. N. R. F.	7 months.
	Lieut. (j. g) L. Sperry, U. S. N. R. F.	5 months.
East Coast Powder	Capt. V. A. Kimberly, U. S. Navy	19 months.
	Lieut. (j g.) Earl A Munyan	17 months.
	Ensign A. W. Phillips, U. S. N. R. F.	8 months.
	Ensign R O Phillips, U S. N. R. F.	Do.
	Ensign Douglas G Stewart, U. S. N. R. F.	10 months.
	Ensign Donald G. Huston, U. S. N. R. F.	5 months.
	Ensign George A. Wrisley, U. S. N. R. F.	Do.
	Ensign Harold J Swezey, U. S. N. R. F.	4 months.
	Ensign Howard S. Lyon, U. S. N. R. F.	Do.
	Ensign George B. Bittings, U. S. N. R. F.	8 months.
	Ensign (T) Horace B. Cosler	2 months.
	Lieut. (j. g.) D. G. Stewart, U. S. N. R. F.	12 months.
New Jersey district	C[illegible]vy (ret.)	Do.
	L[illegible]S. N. R. F.	14 months.
	L[illegible]S. N. R. F.	12 months.
	E[illegible]N. R. F.	11 months.
	E[illegible]R. F.	10 months.
	L[illegible]vy	19 months.
	L[illegible]U. S. N. R. F.	8 months.
	E[illegible]R. F.	6 months.
	E[illegible]N. R. F.	3 months.
	E[illegible]N. R. F.	Do.
	L[illegible]N. R. F.	2 months.
	E[illegible]N. R. F.	1 month.
	L[illegible]R. F.	12 months.
	E[illegible]S. Navy	1 month.
	E[illegible]	Do.
	L[illegible]F.	12 months.
	E[illegible]F.	2 weeks.
	L[illegible]R. F.	10 months.
	E[illegible]	8 months.

[1] Also 7 months in New Jersey district.
[2] Also 6 months at Bliss Co.

Officers on duty in the bureau's inspection force between Apr. 6, 1917, and Nov. 11, 1918—Continued.

Plant or district.	Officers.	On duty.
New England district	Lieut. Comdr. J. B. Staley, U. S. Navy	19 months.
	Lieut. S. C. Mastick, U. S. N. R. F	17 months.
	Chief Carpenter C. E. Richardson, U. S. Navy (ret.)	19 months.
	Lieut. Franklin Farrell, U. S. N. R. F	14 months.
	Ensign R. S. Tufts, U. S. N. R. F	6 months.
	Ensign Phillip T. Hill, U. S. N. R. F	10 months.
	Ensign Frank S. Dohrman, U. S. N. R. F	11 months.
	Ensign Edson H. Smith, U. S. N. R. F	10 months.
	Ensign Charles B. Phelps, U. S. N. R. F	Do.
	Lieut. John F. Easterbrook, U. S. N. R. F	Do.
	Ensign John Tetlow, U. S. N. R. F	9 months.
	Ensign Walter G. Taft, U. S. N. R. F	4 months.
	Ensign Raymond K. Hyde, U. S. N. R. F	Do.
	Ensign Arthur G. Smith, U. S. N. R. F	3 months.
	Lieut. (j. g.) Wm. A. Needham, U. S. N. R. F	Do.
	Ensign T. J. Moore, U. S. N. R. F	9 months.
	Gunner W. Carroll, U. S. Navy	4 months.
Munhall inspection district	Commander R. R. Adams, U. S. Navy	19 months.
	Lieut. Comdr. E. H. Reed, U. S. N. R. F	14 months.
	Lieut. N. R. Wilber, U. S. N. R. F	15 months.
	Lieut. D. C. Daniels, U. S. N. R. F	14 months.
	Ensign Louis Mardaga, U. S. N. R. F	10 months.
	Lieut. (j. g.) S. H. H. Parsons, U. S. N. R. F	Do.
	Lieut. (j. g.) H. S. Brainerd, U. S. N. R. F	12 months.
	Ensign S. L. Kring, U. S. N. R. F	10 months.
	Lieut. (j. g.) L. B. Evans, U. S. N. R. F	Do.
	E[illegible] N. R. F	Do.
	E[illegible] N. R. F	6 months.
	L[illegible] S. Navy	8 months.
	E[illegible] N. R. F	Do.
	L[illegible] R. F	6 months.
	L[illegible] S. Navy	4 months.
	E[illegible] R. F	2 months.
	E[illegible] U. S. N. R. F	4 months.
	E[illegible] S. Navy	1 month.
	L[illegible] N. R. F	3 months.
	E[illegible] F	6 weeks.
	E[illegible] U. S. Navy	Do.
	E[illegible] N. R. F	Do.
	E[illegible] F	1 month.
	E[illegible] F	2 weeks.
	E[illegible] S. Navy	6 weeks.
	E[illegible] F	4 weeks.
	E[illegible] N. R. F	3 months.
	E[illegible] F	2 weeks.
	E[illegible] R. F	3 weeks.
	E[illegible] R. F	6 weeks.
	E[illegible] R. F	2 months.[1]
	L[illegible] Navy	6 months.
	L[illegible] R. F	4 months.
	L[illegible] S. N. R. F	11 months.
	L[illegible] N. R. F	6 months.
	E[illegible] N. R. F	(2)
[illegible]ago inspection district	Commander Horace W. Jones, U. S. Navy (ret.)	19 months.
	Lieut. W. A. Lee, U. S. Navy	Do.
	Lieut. Ora B. Cahoon, U. S. N. R. F	10 months.
	Carpenter B. D. Pender, U. S. Navy (ret.)	18 months.
	Lieut. (j. g.) G. H. Crocker, U. S. N. R. F	14 months.
	Lieut. (j. g.) Henry B. Freeman, U. S. N. R. F	11 months.
	Ensign Raymond H. Coulter, U. S. N. R. F	10 months.
	Ensign William S. Green, U. S. N. R. F	Do.
	Lieut. (j. g.) Keith Williams, U. S. N. R. F	3½ months.
	Ensign J. P. VanVorst, U. S. N. R. F	2 months.
	Ensign Charles A. Singer, U. S. N. R. F	3 months.
	Ensign (T.) William N. McGowan, U. S. Navy	2 months.
	Ensign Harold E. Lucker, U. S. N. R. F	Do.
	Ensign McKendree Kimberly, U. S. N. R. F	4 months.
	Ensign W. H. Holby, U. S. N. R. F	1 month.
	Ensign George C. Crabtree, U. S. N. R. F	10 months.
	Ensign D. D. Barnes, U. S. N. R. F	3 months.
	Ensign S. F. Bates, U. S. N. R. F	5 months.[3]

[1] Deceased.
[2] Foreign service.
[3] Also 5 months at Washington Navy Yard.

Officers on duty in the bureau's inspection force between Apr. 6, 1917, and Nov. 11, 1918—Continued.

Plant or district.	Officers.	On duty.
Midvale inspection district	Commander A. C. Diffenbach, U. S. Navy (ret.)	19 months.
	Lieut. Comdr. E. R. Mason, U. S. N. R. F.	15 months.
	Lieut. (j. g.) Howard N. Ingham, U. S. N. R. F.	10 months.
	Lieut. (j. g.) F. H. Fowler, U. S. N. R. F.	8 months.
	Lieut. Orange M. McNiel, U. S. N. R. F.	Do.
	Ensign Alfred R. Edwards, U. S. N. R. F.	10 months.
	Lieut. (j. g.) Marvin L. Brown, U. S. N. R. F.	11 months.
	Ensign H. K. M. Grylls, U. S. N. R. F.	8 months.
	Ensign Henry R. Sampson, U. S. N. R. F.	6 months.
	Lieut. (j. g.) Geo. T. Ladd, U. S. N. R. F.	5 months.
	Ensign James E. Chadderton, U. S. N. R. F.	4 months.
	Ensign W. C. Wright, U. S. N. R. F.	2 months.
	Lieut. (j. g.) A. H. Showalter, U. S. N. R. F.	3 months.
	Lieut. Henry W. Brooks, U. S. N. R. F.	Do.
	Lieut. D. C. Buell, U. S. N. R. F.	9 months.
	Ensign P. T. Raymond, U. S. N. R. F.	2 months.[1]
Bethlehem District	Lieut. Comdr. E. P. Finney, U. S. Navy	11 months.
	Commander W. D. Greetham, U. S. Navy	3 months.
	Lieut. (j. g.) Floyd M. Fuller, U. S. N. R. F.	10 months.
	Lieut. (j. g.) Frederick P. Lilley, R. F.	7 months.
J. B. Semple & Co., Sewickley, Pa	Commander J. H. Rohrbacher, U. S. Navy (ret.)	19 months.
District of Columbia District, Washington Steel & Ordnance Co.	Commander E. H. Connor, U. S. Navy	11 months.
	Commander G. E. Brandt, U. S. Navy	1 month.
Southeastern District, Birmingham, Ala.	Lieut. (j. g.) Leon H. Webber, U. S. N. R. F.	12 months.[2]
Maryland District	Lieut. Gilford Darst, U. S. Navy (ret.)	19 months.
	Ensign C. B. Covington, U. S. N. R. F.	8 months.
Newport News Shipbuilding & Dry Dock Co.	Commander George Mallison, U. S. Navy (ret.)	19 months.
New York Shipbuilding Co., Camden, N. J.	Commander E. S. Jackson	14 months.
	Lieut. J. S. Lowell, U. S. Navy	19 months.
	Chief Gunner C. Dugan, U. S. Navy (ret.)	Do.
	Lieut. (j. g.) A. P. Nicholson, U. S. N. R. F.	11 months.
	Ensign Richard R. Warren, U. S. N. R. F.	1 month.
Inspection of Ordnance, optical material.	Lieut. C. H. Davis, U. S. Navy	8 months.
	Ensign (T.) F. J. M. Parduhn, U. S. Navy	19 months.
	Ensign Philip F. Hambsch, U. S. Navy (ret.)	7 months.
	Ensign C. W. Barker, U. S. N. R. F.	8 months.
	Lieut. (j. g.) F. L. Mason, U. S. N. R. F.	5 months.
	Machinist James B. Nolan, U. S. Navy	6 months.
	Machinist Charles B. Bell, U. S. Navy	4 months.
	Ensign Charles Bittinger, U. S. N. R. F.	7 months.
	Ensign W. A. Blocher, U. S. N. R. F.	3 months.
	Machinist Wm. J. Brockie, U. S. Navy	Do.
	Ensign H. B. Dugan, U. S. N. R. F.	2½ months.
	Gunner Charles G. Dyson, U. S. Navy	3 months.
	Carpenter Eric Gugler, U. S. Navy	7 months.
	Ensign (T.) Charles Swanberg, U. S. Navy	19 months.
U. S. Naval Gun Factory, Optical Shop Annex, Rochester, N. Y.	Lieut. Comdr. L. C. Scheibla, U. S. Navy	11 months.
	Machinist H. H. Brotzmann, U. S. Navy	Do.
	Lieut. (j. g.) E. S. Carfolite, U. S. Navy	10 months.
	Machinist (T.) Nels Hage, U. S. Navy	13 months.
	Commander F. P. Sackett (S. C.) U. S. Navy	1 month.
	Ensign H. M. Schiffer (S. C.) U. S. Navy	10 months.
	Ensign A. B. Sharp (S. C.) U. S. N. R. F.	7 months.
	Machinist J. B. Nolan, U. S. Navy	6 months.
Fore River Shipbuilding Co., Quincy, Mass.	Commander S. E. Moses, U. S. Navy	10 months.
	Commander Rufus F. Zogbaum, U. S. Navy	2 months.
	Lieut. (j. g.) A. S. Pennell, U. S. N. R. F.	8 months.
	Commander A. H. MacCarthy, U. S. N. R. F.	7 months.
Seattle Construction & Dry Dock Co., Seattle, Wash.	Commander W. W. Bush (ret.)	17 months.
California Shipbuilding Co., Long Beach, Calif.	Lieut. Comdr. Irving H. Mayfield	15 months

[1] Also 6 months special duty at Philadelphia yard with railway battery.
[2] Deceased.

Officers on duty in the bureau's inspection force between Apr. 6, 1917, and Nov. 11, 1918—Continued.

Plant or district.	Officers.	On duty.
Union Iron Works, San Francisco, Calif.	Commander H. G. Leopold, U. S. Navy (ret.)	18 months.
General Electric Co., Schenectady, N. Y.	Lieut. Comdr. C. Baily, U. S. Navy (ret.)	19 months.
	Commodore J. T. Newton, U. S. Navy (ret.)	Do.
New London Ship & Engine Building Co., Groton, Conn.	Lieut. Holbrook Gibson, U. S. Navy	7 months.
Bath Iron Works, Bath, Me	Commander Edwin Delany, U. S. Navy (ret.)	19 months.
Lake Torpedo Boat Co., Bridgeport, Conn.	Lieut. Comdr. D. C. Laizure, U. S. Navy	18 months.
Boston, Mass	Commodore B. T. Walling, U. S. Navy (ret.)	19 months.[1]
Maryland Pressed Steel Co., Hagerstown, Md.	Capt. Armisted Rust, U. S. Navy (ret.)	11 months.
	Lieut. T. C. Wester, U. S. Navy (ret.)	6 months.[2]
Naval Gun Factory, Navy Yard, Washington, D. C.	Lieut. F. T. Applegate, U. S. Navy	11 months.
	Machinist H. H. Brotzman, U. S. Navy	Do.
	Lieut. W. A. Cable, U. S. Navy	19 months.
	Lieut. (j. g.) E. S. Carfolite, U. S. Navy	10 months.
	Lieut. Comdr. Curley, U. S. Navy	5 months.
	Lieut. Comdr. H. Frankenberger, U. S. Navy (ret.)	19 months.
	Lieut. (T.) (G.) E. W. Furey, U. S. Navy	Do.
	Lieut. M. W. Gilmartin, U. S. Navy	Do.
	Machinist (T.) Nels Hage, U. S. Navy	11 months.
	Lieut. (T.) (G.) T. J. Hurd, U. S. Navy	19 months.
	Lieut. Simon Jacobs, U. S. Navy	6 months.
	Commander R. C. McFall, U. S. Navy	9 months.
	Commander E. J. Marquart, U. S. Navy	19 months.
	Lieut. (T.) (M.) J. H. Morrison, U. S. Navy	2 months.
	Lieut. (T.) (G.) J. T. Roach, U. S. Navy	19 months.
	Lieut. Comdr. A. G. Zimmerman, U. S. Navy	9 months.
	Lieut. John J. Walsh, U. S. Navy (ret.)	Do.
	Lieut. (j. g.) L. B. Altreuter, U. S. N. R. F	16 months.
	Ensign S. F. Bates, U. S. N. R. F	5 months.
	Lieut. Alva D. Bernhard, U. S. Navy	8 months.
	Lieut. (j. g.) F. C. Boardman, U. S. Navy	5 months.
	Lieut. (j. g.) R. U. Bunker, U. S. N. R. F	6 months.
	Lieut. V. K. Coman, U. S. Navy	4 months.
	Ensign A. J. Cook, U. S. N. R. F	8 months.
	Commander G. McC. Courts, U. S. Navy	19 months.
	Lieut. (j. g.) R. M. Critchfield, U. S. N. R. F	10 months.
	Comdr. H. Delano, U. S. Navy	14 months.
	Ensign Walter C. Gielow, U. S. N. R. F	1 month.
	Ensign Henry A. Hanson, U. S. N. R. F	2 months.
	Ensign James H. Howard, U. S. N. R. F	1 month.
	Lieut. Comdr. F. H. Kelly, U. S. Navy	14 months.
	Lieut. Comdr. M. Kelly, U. S. Navy	15 months.
	Lieut. (j. g.) E. P. Knollman, U. S. N. R. F	6 months.
	Lieut. (j. g.) G. Q. Lewis, U. S. N. R. F	10 months.
	Lieut. (j. g.) L. D. Loughran (S. C.), U. S. N. R. F.	2 months.
	Lieut. (j. g.) E. C. McGill, U. S. N. R. F. (M. C.)	4 months.
	Pay Clerk R. S. Marting, U. S. N. R. F	6 months.
	Ensign S. H. Oviatt, U. S. N. R. F	2 months
	Ensign F. H. Prescott, U. S. N. R. F	1 month.
	Lieut. (j. g.) T. D. Rogers, U. S. N. R. F	4 months.
	Lieut. Comdr. G. C. Scott (C. E. C.), U. S. N. R. F	19 months.
	Ensign R. W. Spear, U. S. N. R. F	1 month.
	Lieut. (j. g.) C. F. Taylor, U. S. Navy	12 months.
	Capt. D. E. Theleen, U. S. Navy	13 months.
	Capt. A. L. Willard, U. S. Navy	19 months.

[1] Also inspector of machinery.
[2] Also 1 month with General Electric Co. and 12 months with Savage Arms Co.

Officers on duty in the bureau's inspection force between Apr. 6, 1917, and Nov. 11, 1918—Continued.

Plant or district.	Officers.	On duty. From—	On duty. To—
Naval proving ground, Indian Head, Md.	Lieut. (T.) (G.) Harry Adams, U. S. Navy.	May 27, 1918	Nov. 11, 1918
	Ensign H. L. Bodfish, U. S. N. R. F.	June 22, 1918	Do.
	Lieut. Comdr. W. H. Caldwell, U. S. N. R. F.	Feb. 4, 1918	Do.
	Lieut. Comdr. S. A. Clement, U. S. Navy.	Jan. 29, 1918	Do.
	Lieut. R. A. Darling, U. S. N. R. F.	June 28, 1918	Do.
	Lieut. W. Eberlin (T.) (G.)	Apr. 6, 1917	Do.
	Ensign L. A. Rehfuss, U. S. N. R. F.	May 27, 1918	Do.
	Ensign W. C. Rehfuss, U. S. N. R. F.	do	Do.
	Capt. H. E. Lackey	May 6, 1917	Do.
	Lieut. (j. g.) (T.) W. H. Leitch	Sept. 15, 1917	Do.
	Machinist F. C. Lutz, U. S. Navy (ret.)	Aug. 1, 1918	Do.
	Gunner (T.) M. W. McClintock, U. S. Navy.	Nov. 9, 1918	Do.
	Capt. C. L. Eichmann, U. S. M. C.	July 3, 1917	Do.
	Lieut. (C. E. C.) J. L. McDonald, U. S. Navy.	Nov. 12, 1917	Do.
	Comdr. C. W. Mauldin, U. S. Navy	Apr. 6, 1917	Do.
	Lieut. (T.) C. J. Naprstek, U. S. Navy	Oct. 22, 1917	Do.
	Lieut. (j. g.) Courtney Williams, U. S. N. R. F.	Sept. 17, 1918	Do.
	Lieut. (T.) (G.) W. Seyford, U. S. Navy	Apr. 6, 1917	Do.
	Ensign E. H. Barclay, U. S. N. R. F.	Sept. 3, 1918	Do.
	Lieut. T. T. Bower, U. S. N. R. F.	Sept. 22, 1918	Oct. 11, 1918
	Lieut. (j. g.) B. L. Browning, U. S. N. R. F. (M. C.) (deceased).	Mar. 1, 1918	June 12, 1918
	Ensign Henry R. Byers, U. S. N. R. F.	Sept. 3, 1918	Nov. 11, 1918
	Lieut. Comdr. J. A. Byrne, U. S. Navy	Nov. 15, 1916	Do.
	Ensign H. L. Crowley, U. S. N. R. F.	July 13, 1918	Do.
	Lieut. Swepson Earle, U. S. N. R. F.	Apr. 2, 1918	Do.
	Lieut. Comdr. Walter C. Espach, U. S. Navy (M. C.).	June 12, 1918	Do.
	Lieut. (j. g.) Joseph M. Gateley, U. S. Navy.	Apr. 16, 1918	Nov. 2, 1918
	Lieut. (j. g.) Walter H. Harper, U. S. N. R. F. (M. C.).	Aug. 29, 1918	Nov. 11, 1918
	Gunner H. T. Hausten, U. S. Navy	Aug. 8, 1918	Do.
	Ensign C. Jansen, U. S. N. R. F.	Dec. 6, 1917	Do.
	Lieut. Comdr. A. G. Kirk, U. S. Navy	Apr. 6, 1917	Do.
	Lieut. Paul Ketzer, U. S. N. R. F.	Oct. 31, 1918	Do.
	Lieut. (j. g.) W. J. Lee, U. S. N. R. F.	Oct. 3, 1918	Do.
	Ensign (S. C.) Phillip H. Levey, U. S. N. R. F.	Sept. 4, 1918	Do.
	Ensign (S. C.) T. B. Mudd, U. S. N. R. F.	Sept. 18, 1918	Do.
	Ensign Roger L. Putnam, U. S. N. R. F.	June 20, 1918	Do.
	Ensign Lee W. Rockwell, U. S. N. R. F.	Sept. 11, 1918	Do.
	Lieut. (j. g.) J. K. Stewart, U. S. N. R. F.	Aug. 17, 1918	Do.
	Ensign S. G. Stocker, U. S. N. R. F.	Aug. 2, 1918	Do.
	Lieut. Henry S. Tierney, U. S. N. R. F.	Apr. 6, 1917	Do.
	Lieut. (S. C.) W. E. Todd, U. S. Navy	do	Do.
	Lieut. (j. g.) Wm. C. Waddell, U. S. N. R. F.	July 8, 1918	Do.
Naval torpedo station, Newport, R. I	Lieut. (T.) (G.) C. H. Anderson, U. S. Navy.	Sept. 17, 1917	Do.
	Lieut. (T.) (G.) G. Bradley, U. S. Navy	July 23, 1917	Do.
	Gunner (T.) W. H. Cady, U. S. Navy	July 26, 1918	Do.
	Lieut. (T.) (G.) Jack K. Campbell, U. S. Navy.	Jan. 16, 1918	Do.
	Lieut. (j. g.) W. C. Carr, U. S. Navy	Apr. 6, 1917	Do.
	Lieut. Comdr. S. O. Greig, U. S. Navy	Apr. 10, 1917	Do.
	Lieut. Comdr. R. J. Hartung, U. S. Navy (ret.).	Mar. 4, 1918	Do.
	Comdr. G. S. Hathaway, U. S. Navy (M.C.)	Oct. 23, 1917	Do.
	Lieut. Comdr. N. W. Hibbs, U. S. Navy	July 27, 1918	Do.
	Second Lieut. O. A. Hill, U. S. M. C.	Oct. 31, 1918	Do.
	Gunner (T.) W. H. Hughes, U. S. Navy	Sept. 17, 1917	Do.
	Gunner (T.) J. J. Jesso, U. S. Navy	Feb. 16, 1918	Do.
	Gunner (T.) Henry C. McClure, U. S. Navy	July 11, 1918	Do.
	Lieut. (S. C.) H. L. Miller, U. S. Navy	Nov. 27, 1917	Do.
	Lieut. Comdr. J. W. Morse, U. S. Navy (S. C.).	July 5, 1918	Do.
	Lieut. G. E. Mott, U. S. N. R. F. (M. C.)	Aug. 13, 1918	Do.
	Lieut. T. J. Mulcahy, U. S. Navy (P. C.)	Apr. 1, 1918	Do.
	Lieut. (T.) (M.) James Newell, U. S. Navy.	Oct. 27, 1917	Do.
	Lieut. W. A. Nichols, U. S. Navy	Feb. 4, 1918	Do.
	Lieut. (T.) (G.) R. M. O'Connor, U. S. Navy.	Apr. 6, 1917	Do.
	Lieut. H. H. Reynolds, U. S. Navy (S. C.)	do	Do.
	Gunner (T.) S. Schnelle, U. S. Navy	do	Do.

Officers on duty in the bureau's inspection force between Apr. 6, 1917, and Nov. 11, 1918—Continued.

Plant or district.	Officers.	On duty.	
		From—	To—
Naval torpedo station, Newport, R. I.	Carpenter (T.) A. O. Stewart, U. S. Navy	Sept. 28, 1917	Nov. 11, 1918
	Capt. M. E. Trench, U. S. Navy	Oct. 1, 1917	Do.
	Lieut. Comdr. F. E. P. Uberroth, U. S. Navy.	Sept. 12, 1918	Do.
	Lieut. (T.) (G.) T. B. Watson, U. S. Navy	Apr. 10, 1918	Do.
	Lieut. (T.) (G.) H. V. Barr, U. S. Navy	Apr. 8, 1917	Do.
	Capt. S. A. Beard, U. S. M. C.	Sept. 6, 1918	Do.
	Lieut. (j. g.) J. B. Becker, U. S. N. R. F.	Sept. 24, 1918	Do.
	Capt. E. L. Beach, U. S. Navy	Apr. 6, 1917	Sept. 12, 1918
	Ensign E. D. Berry, U. S. Navy	Jan. 16, 1918	Apr. 23, 1918
	Ensign H. C. Brown, U. S. Navy	Jan. 18, 1918	Feb. 12, 1918
	Lieut. (j. g.) C. E. Colahan, U. S. N. R. F.	June 1, 1917	Oct. 1, 1918
	Ensign E. B. Condon, U. S. N. R. F.	Aug. 29, 1918	Nov. 11, 1918
	Ensign J. D. Cornell, U. S. Navy	Jan. 18, 1918	May 10, 1918
	Gunner (T.) F. W. Crilley, U. S. Navy	Sept. 28, 1917	Oct. 18, 1918
	Ensign (T.) (G.) L. Crilley, U. S. Navy	Jan. 18, 1918	Jan. 25, 1918
	Ensign R. H. Davison, U. S. N. R. F.	May 23, 1917	Jan. 17, 1918
	Ensign (T.) (G.) S. J. Drellishak, U. S. Navy.	Jan. 18, 1918	Feb. 12, 1918
	Lieut. R. M. Elliot, U. S. Navy	Apr. 6, 1917	Nov. 11, 1918
	Lieut. Comdr. M. T. Eppley, U. S. Navy	Mar. 22, 1918	Do.
	Ensign Roger A. Fowler, U. S. N. R. F.	Sept. 1, 1918	Do.
	Ensign V. O. Freeburg, U. S. N. R. F.	Aug. 30, 1918	Do.
	Comdr. H. F. Glover, U. S. Navy	July 30, 1917	Do.
	Lieut. (j. g.) W. T. Hall, U. S. Navy	Apr. 6, 1917	Do.
	Gunner (T.) Robert S. Hazlett, U. S. Navy.	July 1, 1918	Do.
	Ensign J. C. Heck, U. S. Navy	Apr. 6, 1917	Oct. 18, 1918
	Lieut. Comdr. A. G. Howard, U. S. Navy	...do...	Sept. 24, 1917
	Gunner Frederick E. McCoy, U. S. Navy	July 1, 1918	Nov. 11, 1918
	Lieut. Comdr. Scott B. Macfarlane, U. S. Navy.	Apr. 16, 1917	Do.
	Ensign (T.) E. C. Marheineke, U. S. Navy	Jan. 18, 1918	July 15, 1918
	Lieut. (j. g.) Radford Moses, U. S. Navy	Apr. 6, 1917	Dec. 15, 1917
	Ensign (T.) E. L. Moyer, U. S. Navy	Jan. 18, 1918	Oct. 18, 1918
	Ensign Wm. H. Nobbit, U. S. N. R. F.	Aug. 29, 1918	Nov. 11, 1918
	Gunner (T.) F. E. Norlin, U. S. Navy	Sept. 28, 1917	July 2, 1918
	Carpenter (T.) Gerald C. Oaks, U. S. Navy.	July 1, 1918	Nov. 11, 1918
	Ensign (T.) J. B. O'Reilly, U. S. Navy	Jan. 16, 1918	Apr. 11, 1918
	Ensign (T.) B. M. Parmenter, U. S. Navy	Jan. 18, 1918	Feb. 8, 1918
	Gunner (T.) Andrew Radowicz, U. S. Navy	July 1, 1918	Nov. 11, 1918
	Chief Gunner E. C. Raynor, U. S. Navy	Oct. 3, 1917	Do.
	Ensign (T.) J. D. Rogers, U. S. Navy	Jan. 16, 1918	Apr. 11, 1918
	Ensign (T.) (G.) F. A. Ruff, U. S. Navy	Jan. 18, 1918	Mar. 13, 1918
	Ensign (T.) L. W. Thomas, U. S. Navy	Jan. 16, 1918	May 18, 1918
	Gunner (T.) Edgar F. Russell, U. S. Navy.	July 11, 1918	Nov. 11, 1918
	Lieut. (j. g.) (T.) A. P. Sauerwein, U. S. Navy.	Jan. 16, 1918	Do.
	Lieut. (j. g.) Frank D. Sprague, U. S. N. R. F.	July 3, 1918	Do.
	Pay Clerk D. A. Stevens, U. S. N. R. F.	Mar. 30, 1918	Do.
	Gunner O. H. Strack, U. S. Navy	Sept. 28, 1917	Apr. 5, 1918
	Lieut. H. W. Stratton, U. S. Navy	Apr. 6, 1917	Sept. 20, 1918
	Lieut. (j. g.) E. W. Strother, U. S. Navy	...do...	Oct. 30, 1917
	Capt. J. M. Swinnerton, U. S. M. C.	Jan. 3, 1918	Nov. 11, 1918
	Ensign R. P. Thornton, U. S. N. R. F.	Sept. 5, 1918	Do.
	Lieut. (j. g.) C. D. Tibbals, U. S. Navy	Apr. 6, 1917	May 14, 1918
	Lieut. R. E. Vaughan, U. S. Navy	Feb. 25, 1918	Mar. 4, 1918
	Gunner (T.) John C. Waldan, U. S. Navy	July 1, 1918	Nov. 11, 1918
	Gunner (T.) N. L. Wilcomb, U. S. Navy	Sept. 28, 1917	Apr. 6, 1918
	Ensign John G. Williams, U. S. N. R. F.	Aug. 30, 1918	Nov. 11, 1918
	Ensign (T.) (W. C.) J. K. Ziesel, U. S. Navy.	Sept. 28, 1918	Do.
Naval ordnance plant, South Charleston, W. Va.	Comdr. J. B. Rhodes, U. S. Navy	Feb. 1, 1918	Do.
	Lieut. Comdr. J. L. Riheldaffer, U. S. Navy	Oct. 26, 1918	Do.
	Lieut. David M. Giltinan, U. S. N. R. F.	Feb. 4, 1918	Do.
	Lieut. (P. C.) F. W. Grover, U. S. Navy	July 1, 1918	Do.
	Lieut. G. G. Irwin, U. S. Navy (M. C.)	Feb. 14, 1918	Do.
	Comdr. Wm. A. Merritt, U. S. Navy	Apr. 21, 1918	Sept. 30, 1918
	Lieut. Comdr. Duette W. Rose, U. S. Navy.	Oct. 3, 1918	Nov. 11, 1918
	Lieut. (j. g.) Walter Terry, U. S. N. R. F.	Oct. 21, 1918	Do.
Naval ordnance plant, Dayton, Ohio.	Lieut. A. F. Bassett, U. S. N. R. F.	Jan. 15, 1918	Do.
	Lieut. J. S. Crawford, U. S. N. R. F.	July 5, 1918	Do.
	Lieut. G. F. Jacobs, U. S. N. R. F.	Apr. 9, 1918	Do.
	Ensign W. A. Hamilton, U. S. N. R. F.	Apr. 1, 1918	Do.
	Ensign Eric Hammler, U. . N. R. F.	Nov. 3, 1918	Do.
	Ensign J. J. Lamberty, U. S. N. R. F.	June 7, 1918	Do.

Officers on duty in the bureau's inspection force on Nov. 1, 1919.

Plant or district.	Inspection force.	Remarks.
E. W. Bliss Co., Brooklyn, N. Y.	Lieut. Comdr. H. M. Branham, U. S. Navy.	
	Commander Roger Williams, U. S. Navy..	
	Lieut. (T.) (G.) Wm. J. Creelman, U. S. Navy.	
	Gunner (T.) Charles E. Avery, U. S. Navy.	
	Lieut. (T.) (G.) A. S. Pearson, U. S. Navy.	
	Lieut. (T.) (G.) Leroy Rodd, U. S. Navy..	
	Lieut. (T.) (G.) C. S. Schepke, U. S. Navy.	
	Lieut. Frederick T. Walling, U. S. Navy..	
	Chief Gunner F. L. Hoagland, U. S. Navy.	
	Gunner (T.) C. E. Heineman, U. S. Navy..	
	Chief Gunner T. Nylund, U. S. Navy......	
Sperry Gyroscope Co. and Ford Instrument Co., Brooklyn, N. Y.	Commander J. S. Arwine, U. S. Navy.....	
	Lieut. (T.) (G.) G. W. Waldo, U. S. Navy.	
	Lieut. (j. g.) N. L. Stevens, U. S. N. R. F..	
New York and New Jersey Districts.	Capt. H. E. Cook, U. S. Navy.............	
	Lieut. Maxwell Case, U. S. Navy..........	
	Lieut. Comdr. A. T. Chester, U. S. N. R. F.	
	Capt. A. A. Ackerman, U. S. Navy (ret.)...	
New England District........	Lieut. Commdr. J. F. Cox, U. S. Navy....	
	Lieut. J. F. Easterbrook.................	
Munhall Inspection District...	Lieut. Comdr. J. B. Rutter, U. S. Navy...	
	Lieut. Asa Watson, U. S. Navy...........	
	Lieut. Albert Klinger, U. S. Navy........	
	Lieut. Albert G. Martin, U. S. Navy.......	
	Lieut. Oscar Smith, U. S. Navy...........	
Chicago Inspection District...	Commander H. W. Jones, U. S. Navy (ret.)	
	Commander W. H. Allen, U. S. Navy.....	
Midvale Inspection District...	Commander A. C. Diffenbach, U. S. Navy (ret.).	
	Capt. Geroge T. Pettingill, U. S. Navy....	
Bethlehem District............	Commander W. D. Greetham, U. S. Navy.	
District of Columbia and Maryland District.	Commander G. E. Brandt, U. S. Navy....	
Southeastern District.........	Lieut. (T.) (G.) William Zeitler, U. S. Navy.	
New York Shipbuilding Co. and Cramps Shipyard.	Commander C. F. Russell, U. S. Navy.....	
	Lieut. Comdr. O. C. Badger, U. S. Navy...	
	Lieut. (T.) (G.) E. C. Wurster, U. S. Navy.	
Bethlehem Shipbuilding Co., Quincy, Mass.	Commander T. A. Kittinger, U. S. Navy..	
Lake Torpedo Boat Co., Bridgeport, Conn.	Commander R. G. Thomas, U. S. Navy...	
Todd Dry Dock & Construction Co., Tacoma, Wash.	Commander Albert Norris, U. S. Navy....	
Inspection of ordnance, optical material.	Lieut. Comdr. J. H. Magruder, U. S. Navy	
	Lieut. Charles F. Merrill, U. S. Navy.....	
	Machinist J. B. Nolan, U. S. Navy........	
Naval Proving Ground, Indian Head, Md.	Lieut. (T.) (G.) Harry Adams, U. S. Navy.	
	Lieut. Comdr. W. H. Caldwell U. S. N. R. F.	
	Lieut. Comdr. S. A. Clement, U. S. Navy.	
	Lieut. R. A. Darling, U. S. N. R. F.......	
	Ensign P. H. Brazeal, U. S. N. R. F.......	Commanding officer subchaser 23.
	Lieut. Glenn B. Davis, U. S. Navy.......	Student officer, ordnance class.
	Lieut. (T.) (G.) W. Eberlin, U. S. Navy..	Battery officer.
	Ensign (T.) H. G. Erwin, U. S. Navy.....	Commanding officer subchaser 192.
	Ensign Paul F. Fagan, U. S. N. R. F.....	Assistant to public works officer.
	Gunner (T.) William A. Gerdts, U. S. Navy.	Student officer, ordnance class.
	Lieut. R. H. Gifford, U. S. Navy.........	Assistant to public works officer.
	Lieut. Comdr. N. C. Gillette, U. S. Navy..	Student officer, ordnance class.
	Lieut. (T.) Augustus K. Goffe, U. S. Navy.	North battery officer.
	Lieut. Comdr. Fitzhugh Green, U. S. Navy	Proof officer.
	Lieut. C. C. Groff, U. S. N. R. F..........	
	Lieut. Albert M. Hinman, U. S. Navy....	Personnel officer.
	Lieut. (T.) C. F. Holzermer, U. S. Navy..	

Officers on duty in the bureau's inspection force on Nov. 1, 1919—Continued.

Plant or district.	Inspection force.	Remarks.
Naval Proving Ground, Indian Head, Md.	Lieut. Comdr. J. C. Jones, U. S. Navy	Student officer, ordnance class.
	Capt. H. E. Lackey, U. S. Navy	Inspector ordnance in charge.
	Lieut. (T.) W. H. Leitch, U. S. Navy	Transportation officer.
	Lieut. Comdr. Howard L. Lewis, U. S. Navy.	Experimental officer.
	Machinist F. C. Lutz, U. S. Navy (ret.)	Engineer officer.
	Gunner (T.) M. W. McClintock, U. S. Navy.	Assistant to north battery officer.
	Lieut. (C. E. C.) J. L. McDonald, U. S. Navy.	Public works officer.
	Lieut. Comdr. (S. C.) E. H. Douglass, U. S. Navy.	Supply officer.
	Capt. C. L. Eichmann, U. S. M. C	Commanding officer Marines.
	Capt. L. R. Jones, U. S. M. C	Assistant to commanding officer Marines.
	Lieut. Comdr. E. R. McClung, U. S. Navy.	
	Commander C. W. Mauldin, U. S. Navy	Assistant inspector ordnance in charge.
	Lieut. Comdr. J. C. Miller, U. S. Navy	Student officer, ordnance class.
	Lieut. (T.) C. J. Naprstek, U. S. Navy	Engineer officer powder factory.
	Pay Clerk R. H. Nessenthaler, U. S. Navy.	Assistant to supply officer.
	Ensign H. C. Patterson, U. S. N. R. F	Assistant to proof officer.
	Ensign Louis A. Rehfuss, U. S. N. R. F	Assistant to officer in charge.
	Ensign W. C. Rehfuss, U. S. N. R. F	Do.
	Lieut. (j. g.) G. S. Rentz, U. S. Navy	Chaplain.
	Lieut. (j. g.) Eldred J. Richards, R. F	West battery officer.
	Lieut. (T.) W. Seyford, U. S. Navy	Naval ammunition officer.
	Lieut. (j. g.) Paul C. Spangler, R. F. (M. C.).	Assistant to medical officer.
	Lieut. Comdr. R. J. Trout (M. C.)	
	Lieut. (j. g.) Courtney Williams	Assistant to proof officer.
Naval Gun Factory, navy yard, Washington, D. C.	Lieut. (T.) (G.) F. T. Applegate, U. S. Navy.	Assistant to inspector allowance.
	Machinist H. H. Brotzman, U. S. Navy	Assistant to inspector optical.
	Lieut. (T.) (G.) W. A. Cable, U. S. Navy.	Assistant to senior inspector.
	Lieut. (j. g.) E. S. Carfolite, U. S. Navy	Assistant to inspector optical.
	Lieut. Comdr. H. P. Curley, U. S. Navy.	Inspector torpedoes.
	Lieut. A. B. Dorsey, U. S. Navy	Assistant to inspector allowance.
	Lieut. Comdr. H. Frankerberger (ret.)	Inspector optical.
	Lieut. (T.) (G.) E. W. Furey, U. S. Navy.	Magazine officer.
	Lieut. (T.) (G.) M. W. Gilmartin, U. S. Navy.	Survey and repair officer.
	Rear Admiral A. W. Grant, U. S. Navy	Commandant and superintendent Naval Gun Factory.
	Machinist (T.) Nels Hage, U. S. Navy	Assistant to inspector optical.
	Lieut. (T.) (G.) Franklin Heins, U. S. Navy.	Magazine officer.
	Capt. W. M. Hunt, U. S. Navy	Senior inspector.
	Lieut. (T.) (G.) T. J. Hurd, U. S. Navy	Assembling officer.
	Lieut. E. V. Isaacs, U. S. Navy	Inspector munitions.
	Lieut. (T.) (G.) Simon Jacobs, U. S. Navy.	Assistant to inspector broadside batteries.
	Commander R. C. McFall, U. S. Navy	Inspector allowance.
	Commander L. N. McNair, U. S. Navy	Inspector planning.
	Capt. C. B. McVay, U. S. Navy	Assistant superintendent.
	Commander E. J. Marquart, U. S. Navy	Aide to superintendent.
	Lieut. (T.) (G.) W. G. Moore, U. S. Navy.	Commanding officer receiving station.
	Lieut. (T.) (M.) J. H. Morrison, U. S. Navy.	Assistant to inspector optical.
	Commander H. L. Pence, U. S. Navy	
	Lieut. (T.) (G.) J. T. Roach, U. S. Navy	Assistant inspector torpedoes.
	Lieut. (T.) (M.) W. T. Robinson, U. S. Navy.	Assistant inspector optical.
	Lieut. Comdr. W. D. Seed, U. S. Navy	Inspector broadside batteries.
	Lieut. (T.) (G.) Wm. G. Smith, U. S. Navy.	Assistant to ordnance survey officer.
	Commander W. T. Smith, U. S. Navy	Inspector turret.
	Lieut. Comdr. R. K. Turner, U. S. Navy.	Inspector designing.
	Lieut. (T.) (G.) D. B. Vassie, U. S. Navy.	Assistant inspector material.
	Commander W. O. Wallace, U. S. Navy	Assistant to senior inspector.
	Lieut. Comdr. A. G. Zimmerman, U. S. Navy.	Inspector of material.

Officers on duty in the bureau's inspection force on Nov. 1, 1919—Continued.

Plant or district.	Inspection force.	Remarks.
Naval Torpedo Station, Newport, R. I.	Lieut. (T.) (G.) C. H. Anderson, U. S. Navy.	In charge of torpedo storehouse.
	Lieut. (T.) (G.) W. T. Baxter, U. S. Navy.	Survey officer.
	Lieut. (T.) (G.) G. Bradley, U. S. Navy..	In charge test barge No. 2.
	Lieut. Comdr. E. S. R. Brandt, U. S. Navy.	Experimental officer.
	Gunner (T.) J. R. Brenner, U. S. Navy..	Under instruction.
	Gunner (T.) H. T. Bryant, U. S. Navy...	Do.
	Gunner (T.) W. H. Cady, U. S. Navy.....	Do.
	Lieut. (T.) (G.) Jack K. Campbell, U. S. Navy.	Instruction of seaman gunners.
	Lieut. (j. g.) W. C. Carr, U. S. Navy......	Instructor Torpedo Training School.
	Lieut. (T.) (G.) C. Clay, U. S. Navy......	Instructor seaman gunner class.
	Gunner (T.) M. Coffey, U. S. Navy.......	Under instruction.
	Lieut. (T.) (B.) P. J. Deery, U. S. Navy..	In charge of Government landing.
	Lieut. (j. g.) (S. C.) R. J. Dindot, U. S. Navy.	Assistant to supply officer.
	Gunner (T.) N. Drewecki, U. S. Navy....	Under instruction.
	Capt. Marc M. Ducote, U. S. M. C.........	Company commander, barracks detachment.
	Gunner (T.) W. S. Durffee, U. S. Navy...	Under instruction.
	Maj. R. B. Farquharson, U. S. M. C.......	Commanding officer, barracks detachment.
	Lieut. (j. g.) Werner E. Follin, U. S. Navy.	Assistant proof officer.
	Gunner (T.) J. W. Gessel, U. S. Navy....	Under instruction.
	Lieut. Comdr. S. O. Greig, U. S. Navy....	Torpedo inspector.
	Lieut. Comdr. R. J. Hartung (ret.)........	Manufacturing officer.
	Commander G. S. Hathaway, U. S. Navy (M. C.).	Senior medical officer.
	Lieut. Comdr. N. W. Hibbs, U. S. Navy..	Inspection officer and charge of explosives.
	Second Lieut. O. A. Hill, U. S. M. C......	Company officer.
	Chief Pharmacist C. R. Holmes (T.)......	Assistant to medical department.
	Gunner (T.) R. Holt, U. S. Navy.........	Under instruction.
	Lieut. (M. C.) J. M. Huff, U. S. Navy.....	Assistant to senior medical officer.
	Gunner (T.) W. H. Hughes, U. S. Navy..	Under instruction.
	Lieut. (T.) (B.) S. Ingham, U. S. Navy...	Yard boatswain.
	Gunner (T.) W. Jamieson, U. S. Navy...	Under instruction.
	Gunner (T.) J. J. Jesso, U. S. Navy......	Do
	Lieut Raymond S. Kaiser, U. S. Navy...	Experimental department.
	Lieut. S. Kalison, U. S. Navy............	Dentist.
	Gunner (T.) J. A. Kane, U. S. Navy........	Under instruction.
	Gunner (T.) E. V. Kelley, U. S. Navy....	Do.
	Gunner (T.) J. R. Kelley, U. S. Navy.....	Do.
	Gunner (T.) T. L. McCann, U. S. Navy...	Do.
	Gunner (T.) Henry C. McClure, U. S. Navy.	Assistant to executive officer.
	Gunner (T.) J. McNamara, U. S. Navy...	Under instruction.
	Gunner (T.) C. A. Marlin, U. S. Navy....	Do.
	Lieut. (S. C.) H. L. Miller, U. S. Navy...	Assistant to disbursing officer.
	Lieut. Comdr. J. W. Morse, U. S. Navy (S. C.).	Supply officer.
	Lieut. G. E. Mott, U. S. N. R. F. (M. C.).	Assistant to senior medical officer.
	Lieut. T. J. Mulcahy (S. C.), U. S. Navy.	Disbursing officer.
	Second Lieut. A. A. Nelson, U. S. M. C...	Company officer.
	Lieut. (T.) (M.) James Newell, U. S. Navy.	Engineer officer.
	Lieut. W. A. Nichols, U. S. Navy.........	Chaplain.
	Lieut. (T.) (G.) R. M. O'Connor, U. S. Navy.	Resident officer, Rose Island.
	Lieut. H. H. Reynolds (S. C.), U. S. Navy.	Assistant to disbursing officer.
	Gunner (T.) S. Schnelle, U. S. Navy......	Under instruction.
	Gunner (T.) R. V. Spellman, U. S. Navy.	Do.
	Carpenter A. O. Steward, U. S. Navy (T.).	
	Gunner (T.) M. M. Stewart, U. S. Navy..	Do.
	Boatswain (T.) J. A. Sunblom, U. S. Navy.	In charge of tugs and ferries.
	Gunner (T.) J. Svesson, U. S. Navy.......	Under instruction.
	Gunner (T.) W. A. Thompson, U. S. Navy.	Do.
	Commander J. C. Townsend, U. S. Navy.	Executive officer.
	Lieut. (T.) (B.) A. A. Travis, U. S. Navy.	In charge U. S. S. Vesuvius.
	Capt. M. E. Trench, U. S. Navy..........	Inspector of ordnance in charge.
	Lieut. Comdr. F. E. P. Uberroth, U. S. Navy.	Proof officer.
	Gunner (T.) M. B. Wallbrath, U. S. Navy.	Under instruction.

Officers on duty in the bureau's inspection force on Nov. 1, 1919—Continued.

Plant or district.	Inspection force.	Remarks.
Naval torpedo Station, Newport, R. I.	Lieut. T. B. Watson (T.) (G.), U. S. Navy.	Assistant torpedo equipment officer.
	Pay Clerk S. Warner, U. S. Navy	
	Gunner (T.) J. F. Williams, U. S. Navy	Under instruction.
	Gunner G. Williams, U. S. Navy	Do.
Naval Torpedo Station, Alexandria, Va.	Lieut. Henry Guilmette (S. C.), U. S. Navy.	
	Lieut. W. C. Jahnke, (S. C.) U. S. Navy	
	Commander H. V. McKittrick, U. S. Navy.	Executive officer.
	Lieut. (T.) (G.) James A. Martin, U. S. Navy.	
	Capt. W. S. Miller, U. S. Navy	
	Gunner Albert J. Steg, U. S. Navy	
	Lieut. (S. C.) Melvin F. Talbot, U. S. Navy.	
	Lieut. (T.) (G.) C. E. Weickhardt, U. S. Navy.	
	Lieut. Comdr. G. C. Wilson, U. S. Navy (M. C.)	
Naval Ordnance Plant, South Charleston, W. Va.	Lieut. Comdr. W. L. Ainsworth, U. S. Navy.	
	Lieut. C. M. Blackford, U. S. Navy (M.C.).	
	Commander Jesse W. Backus, U. S. Navy (M. C.).	
	Ensign H. L. Bodfish (C. E. C.), R. F.	
	Lieut. J. H. Chase, U. S. Navy	
	Lieut. (T.) (G.) U. G. Chipman, U. S. Navy.	
	Lieut. A. H. Cummings, U. S. Navy	
	Pay Clerk C. R. Fatzer (T.) (S. C.), U. S. Navy.	
	Ensign C. N. E. Fontaine (T.), U. S. Navy.	
	Ensign A. C. Kleppinger, U. S. Navy	
	Capt. George R. Marvel, U. S. Navy	
	Commander W. A. Merritt (S. C.), U. S. Navy.	
	Commander J. B. Rhodes, U. S. Navy	
	Lieut. Comdr. J. L. Riheldaffer, U. S. Navy (T.).	
Naval Ordnance Plant, Dayton, Ohio.	Pay Clerk J. R. Edwards, U. S. Navy	
	Ensign H. C. Davidson, U. S. N. R. F	
	Lieut. Comdr. Oscar Smith, U. S. Navy	
Naval Ordnance Plant, Baldwin, L. I.	Ensign Chas. F. House, U. S. Navy (S.C.).	
	Lieut. Ralph Martin, U. S. Navy	

Leading civilians on inspection force, Nov. 1, 1919.

Location.	Name.	Title.	Date of appointment.
Quincy, Mass	Wallace, Frederick	C. A. I. O	Jan. 1, 1899
Bridgeport	Cornwall, Frederick	S. C. A. I. O	Mar. 14, 1892
	Bradley, Isaac	C. A. I. O	Nov. 12, 1917
Bliss	Miller, H. W	S. C. A. I. O	Sept. 10, 1909
East Coast	Tilley, Geo. P	C. A. I. O	June 3, 1907
New Jersey District	Klein, C. S	S. C. A. I. O	[1] June 11, 1907
	Bilrer, John	C. A. I. O	Sept. 14, 1915
Cramp's	Thomson, N. F	C. A. I. O	Aug. 16, 1893
Midvale	Johnson, Clarence	S. C. A. I. O	Apr. 16, 1913
	Henze, Wm. H	C. A. I. O	Sept. 1, 1904
	Howson, Frank W	do	Dec. 29, 1911
	Berger, Geo. O	do	May 1, 1912
	Breckenridge, A. H	do	Oct. 15, 1917
	Bentley, L. B	do	Oct. 2, 1918
	Boyd, Hugh, jr	do	Apr. 19, 1917
	Gunning, James M	do	Oct. 1, 1915
Munhall, Pa	Henry S. Stites	S. C. A. I. O	Nov. 5, 1917
	Geo. H. Holden	do	Oct. 31, 1918
	Frank W. Groh	do	Do.
	W. L. Blundin	do	Do.
	L. F. Johnson	do	Do.

[1] Appointment S. B., transferred Apr. 9, 1918.

Field inspection force personnel.

District.	Jan. 1, 1917.			Nov. 11, 1918.			
	Officers.	Civilians.	Total.	Officers.	Civilians.	Enlisted.	Total.
New England	1	4	5	14	65	87	166
Midvale	1	17	18	11	78	140	229
Munhall	1	6	7	38	130	281	449
New Jersey	1	7	8	16	28	174	218
Bethlehem	[1] 1	8	9	4	59	14	77
Chicago	1	0	1	15	50	61	126
Southeastern	1	0	1	1	6	1	8
Maryland	0	0	0	2	15	0	17
District of Columbia	1	1	2	1	10	10	21
Northern Pacific	[1] 1	0	1	2	2	1	5
Middle Pacific	0	0	0	3	4	1	8
Southern Pacific	[1] 1	0	1	0	0	0	0
East Coast Powder	1	1	2	13	15	40	68
E. W. Bliss	[2] 2	5	7	14	18	40	72
Bausch & Lomb	[3] 1	0	1	6	11	4	21
J. B. Semple & Co.	0	0	0	1	2	0	3
Ford Instrument & Sperry Co.	0	0	0	5	1	33	39
Bath Iron Works	[1] 1	0	1	1	2	0	3
Cramps Shipyard	1	2	3	3	3	0	6
New York Shipbuilding Co.	1	0	1	3	10	0	13
Newport News Shipbuilding Co.	1	1	2	1	1	1	3
Lake Torpedo Boat Co.	0	0	0	1	1	0	2
New London Ship & Engine Building Co.	[1] 1	0	1	1	4	3	8
Hatfields, Sheffield, England	0	0	0	[4] 1	1	0	2
General Electric Co.	[1] 1	0	1	1	2	0	3
Fore River Shipbuilding Co.	[1] 1	1	2	1	3	4	8
Boston, Mass.	[1] 1	0	1	1	0	0	1
Total	22	53	75	160	521	895	1,576

[1] Duty as inspector of engineering and ordnance.
[2] Six warrant officers—duty and instruction.
[3] Two warrant officers—duty and instruction.
[4] Part of duties as naval attaché.

RECAPITULATION, INSPECTION FORCE PERSONNEL.

	Jan. 1, 1917.	Apr. 1, 1917.	Nov. 11, 1918.	June 30, 1919.	Jan. 1, 1920.
Officers, bureau	1	1	4	2	1
Officers in the field	22	25	160	95	52
Enlisted naval force	0	0	895	175	1
Civilian force	53	69	521	396	331

APPENDIX V.

PERSONNEL.

Personnel under the United States Navy.

Branch.	Feb. 1, 1917.		Nov. 11, 1918.		Nov. 1, 1919.	
	Regular.	Reserve.	Regular.	Reserve.	Regular.	Reserve
Navy:						
Officers	4,173	13	10,489	20,705	10,193	1,809
Enlisted men	57,042	8,813	216,644	277,945	115,647	4,709
Coast Guard:						
Officers	0	0	688	0	0	0
Enlisted men	0	0	5,727	0	0	0
Total	61,215	8,826	233,548	298,650	125,840	6,518
	70,041		532,198		132,358	

Bureau personnel.

	Jan. 1, 1917.	Nov. 1, 1918.	June 30, 1919.	Jan. 1, 1920.
Commissioned officers, United States Navy:				
Active list	12	24	31	32
Retired list	1	10	7	1
Naval Reserve	0	85	21	2
Coast Guard	0	2	1	0
Total United States officers	13	121	60	35
Commissioned officers Royal British Navy	0	2	0	0
Total officers	13	123	60	35
Clerical force:				
Civil service—				
Male	36	35	34	41
Female	0	24	19	72
Naval Reserves—				
Male	0	63	13	0
Female	0	117	67	0
Total clerical force	36	239	133	113
Technicists:				
Civil service (male)	0	2	2	8
Draftsmen:				
Civil service—				
Male	3	20	17	26
Female	0	0	2	1
Naval Reserve—				
Male	0	3	0	0
Female	0	1	0	0
Total draftsmen	3	24	19	27
Grand total	52	388	214	183
Naval Ordnance stations:				
Commissioned officers—				
Regular	87	140	....	175
Reserve	0	84	....	22
Total officers	87	224	....	197

Bureau personnel—Continued.

	Jan. 1, 1917.	Nov. 1, 1918.	June 30, 1919.	Jan. 1, 1920.
Naval Ordnance stations—Continued.				
Civil service—				
Clerical	300	484		637
Drafting	154	249		233
Mechanics and laborers	9,084	16,710		15,962
Naval Reservists (enlisted)—				
Clerical	0	207		0
Drafting	0	67		0
Mechanics and laborers	0	537		0
Total for Naval Ordnance stations	9,625	18,478		17,029

APPENDIX VI.

NEW PLANTS ERECTED.

The following plants were either taken over and operated or built and operated, directly under the control of the Bureau of Ordnance, Navy Department, viz:

United States Naval Ordnance Plant, South Charleston, W. Va. Projectiles, gun forgings, and armor plate. Site of 210.091 acres purchased June 4, 1917. Ground broken for projectile plant August 30, 1917. First steel poured in projectile plant June 8, 1918, and all buildings of projectile plant practically completed August 5, 1918. Intensive construction of the armor plant begun in spring of 1919.

United States Naval Ordnance Plant, Dayton, Ohio (formerly The Recording and Computing Machines Co.) Acquired November 22, 1917. Gear for director system.

United States Naval Ordnance Plant, Baldwin, Long Island, N. Y. (formerly Ordnance Engineering Corporation). Contract dated July 1, 1918. Acquired November 23, 1918. Illuminating projectiles.

The following plants were either substantially built or rebuilt and equipped under contract with the Navy under direction of the Bureau of Ordnance, viz:

Tioga Steel & Iron Co., Philadelphia, Pa. Date of contract August 4, 1917. 8,000,000 pounds of 4-inch gun forgings.

Poole Engineering & Machine Co., Woodberry, Baltimore, Md. Date of contract, August 29, 1917. 500 4-inch guns.

American Radiator Co., Bayonne, N. J. Date of contract, June 7, 1917. 1,000 4-inch guns. Supplemental agreement dated July 18, 1918, for additional 1,000 4-inch guns.

Inland Ordnance Co., Bedford, Ohio. Contract dated July 27, 1917. 5,000,000 pounds of 3-inch and 4-inch gun forgings.

Four Lakes Ordnance Co., Madison, Wis. Contract dated October 11, 1917. 300 5-inch guns.

Erie Forge & Steel Co., Erie, Pa. Contract dated October 24, 1917. 7,500,000 pounds of 4-inch gun forgings.

Alloy Steel Forgings Co., Pittsburgh, Pa. Contract dated December 13, 1917. Gun forgings. Commandeered and operated by the Navy. December 4, 1917.

Boucher Manufacturing Co., New York, N. Y. Contract dated October 8, 1917. Mine material.

Defiance Machine Works, Defiance, Ohio. Contract dated July 30, 1917. 500 3-inch guns.

E. I. du Pont de Nemours & Co., Barksdale, Wis. Contract dated March 8, 1918. 30,000,000 pounds of crude TNX.

The Barrett Co., New York, N. Y. Contract dated June 12, 1918. 2,700,000 gallons of xylol.

EXTENSIONS AND ADDITIONS MADE DURING WAR PERIOD.

A—LAND.

	Acres.
Navy yard, Washington, D. C., 1916–1919	45.00
Powder factory, Indian Head, Md., June 10, 1918	845.00
Powder factory, Indian Head, Md., June 18, 1918	433.00
Lower proving ground, Dahlgren, Va., June 10, 1918	994.00
Lower proving ground, Dahlgren, Va., November 4, 1918	372.00
Lower proving ground, Blackistone Island	97.00
Naval torpedo station, Newport, R. I., August 7, 1918	56.00
Naval ammunition depot, Lake Denmark, N. J., August 7, 1918	59.14
Naval ammunition depot, Fort Mifflin, Pa., August 7, 1918	150.50
Naval ammunition depot, St. Julien's Creek, Va., 1917	143.64
Naval mine depot, Yorkstown, Va., August 7, 1918	11,433.00
Naval torpedo station, Alexandria, Va., 1918	2.60
Munitions storage, New London, Conn., February 18, 1918	26.88
Ordnance plant, Dayton, Ohio, February 5, 1918	2.30
Ordnance plant, Baldwin, N. Y., August 5, 1918	3.03
Ordnance plant, South Charleston, W. Va., June 4, 1917	210.09
Total	14,873.18

B.—CONSTRUCTION.

Navy yard, Washington, D. C.:

New storage building, gun shop, machine shop, pattern shop, brass foundry, steel foundry, optical shop, and forge shop.

St. Juliens Creek, Va.:

Mine-loading plant, comprising 27 buildings, constructed during winter of 1917–18. Designed capacity, 1,000 mines per day of 24 hours. Best record, 1,530 mines in 24 hours. Total mines loaded, 73,000, using 22,000,000 pounds TNT.

Naval powder factory, Indian Head, Md.:

New nitrate house, dehydrating house, ether house, two accumulation houses, press house, machine-shop extension, carpenter shop, two service warehouses, and improved power plant.

Nitrate plant. Estimated capacity, 180,000 pounds of 96 per cent nitric acid per day. Contract dated September 25, 1918. Canceled.

Ammonia plant. Contract dated September 20, 1918. Canceled.

Indian Head Railroad. Contract dated July 15, 1918. Railroad opened May 29, 1919.

Lower proving ground, Dahlgren, Va.:

Construction began May 28, 1918. Wharf, railroad, spur tracks, roads, and storehouses constructed. Administration building, laboratory, hangar, and other buildings under construction.

Naval torpedo station, Alexandria, Va.:

Two buildings erected. Placed in commission June 16, 1919. An assembly, storage, and issue depot for torpedoes.

Naval mine depot, Yorktown, Va.:

Storage for high explosives. Buildings 1 mile apart. Sixteen buildings constructed.

Pacific coast torpedo station, Keyport, Wash.:

Nineteen new buildings erected.

Navy mine depot, New London, Conn.:

Storage depot, for nonexplosive ordnance material. Eleven buildings erected.

Naval mine depots at Ivergordon and Inverness, Scotland:

Designed capacity, 500 mines per day. Best record, 1,340. Buildings furnished by British Admiralty, but extensive alterations were necessary, and railways had to be built. Assembly began soon after April, 1918. First mines laid June 8, 1918.

Naval ammunition depots:

Hingham, Mass., 58 new buildings.
Iona Island, N. Y., 18 new buildings.
Lake Denmark, N. J., 183 new buildings.
Fort Mifflin, Pa., 30 new buildings.
St. Juliens Creek, Va., 48 new buildings.
Mare Island, Calif., 29 new buildings.
Puget Sound, Wash., 12 new buildings.
Kuahua, Hawaii, 5 new buildings.
Charleston, S. C., 3 new buildings.

APPENDIX VII.

ORDNANCE PRODUCTION.

Total amounts of principal items of ordnance, Jan. 1, 1917, to Nov. 30, 1918.

Items.	Contracted for.	Delivered.
Guns:		
Minor caliber	5,663	1,791
Intermediate caliber	5,563	1,042
Major caliber	[1] 61	65
Projectiles:		
Minor caliber	9,878,772	8,227,000
Intermediate caliber	3,232,589	2,570,000
Major caliber	176,669	68,600
Mounts	13,749	3,638
Smokeless powder ... pounds	100,950,000	55,566,476
Torpedoes	5,710	1,982
Depth charges	87,000	56,423
Mines	150,000	102,490
Machine guns	14,902	9,756
Small arms	157,315	90,865
Submarine net material (approximate) ... miles	50	50
Y guns	1,400	1,036
Ammunition boxes	580,000	576,000
Black powder ... pounds	1,500,000	1,276,000
Cartridge bag cloth ... yards	1,650,000	328,714
Cartridges cases	5,721,000	4,424,917
Explosive "D" ... pounds	5,450,000	4,035,000
Fuses	12,603,000	10,800,000
Picric acid ... pounds	20,000	20,000
Primers	14,406,000	12,865,000
Powder tanks	1,131,885	392,160
TNT ... pounds	47,616,614	37,907,000
Tetryl	20,000	18,975
Tracers	800,000	800,000
Pyrotechnic material ... pieces	2,400,000	1,725,250
Small arms ammunition	7,000,000	7,000,000
TNX	30,000,000	228,000

[1] Prior to January, 1917, 20 additional.

ORDNANCE CONTRACTS, PRINCIPAL ITEMS 1917.

	Prior to Jan. 1917.	Jan.	Feb.	Mar.	Apr.	May.	June.
Guns:							
Minor	334			489	2,824	300	200
Intermediate	556		40	213	180	1,000	2,000
Major	20	13					
Projectiles:							
Minor	961,157				2,124,912	1,480,000	560,000
Intermediate	436,149		63,500		428,900	62,600	11,614
Major	15,822	150	10,000	2,275	13,044	7,200	46,600
Mounts	310	100		447	2,568	2,142	242
Smokeless powder ... lbs.			[1] 19,550,000			800,000	17,200,000
Torpedoes				912	2,172	192	
Depth charges						10,000	
Mines							

[1] Prior to April, 1917.

ORDNANCE CONTRACTS, PRINCIPAL ITEMS 1917—Continued.

	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Guns:							
Minor	650	...	...	...		500	4,963
Intermediate	...	500	20	300	...	48	4,301
Major	...	...	...	...	...	...	13
Projectiles:							
Minor	1,692,000	1,300,000	...	460,000	...	99,000	7,715,912
Intermediate	1,000	1,490,075	315,000	...	507,500	...	2,880,189
Major	...	...	5,700	100	...	...	85,069
Mounts	1,000	740	900	325	1,000	1,065	10,529
Smokeless powder......lbs.	...	25,000,000	3,200,000	8,000,000	24,400,000	1,000,000	99,150,000
Torpedoes	...	...	...	...	...	...	3,276
Depth charges	10,000	...	...	...	...	15,000	35,000
Mines	...	...	...	100,000	...	...	100,000

ORDNANCE DELIVERIES, PRINCIPAL ITEMS 1917.

	Prior to Jan. 1917.	Jan.	Feb.	Mar.	Apr.	May.	June.
Guns:							
Minor	...	3	3	4	3	18	27
Intermediate	...	10	6	...	5	1	2
Major	...	3	3	3	1	2	1
Projectiles:							
Minor	...	26,000	23,000	12,000	61,000	231,000	165,000
Intermediate	...	4,000	3,000	11,000	16,000	25,000	30,000
Major	...	200	100	300	1,300	1,100	1,800
Mounts[1]	...	...	...	...	...	...	...
Smokeless powder......lbs.	...	...	...	...	717,525	1,164,120	262,829
Torpedoes	...	75	99	85	23	31	78
Depth charges	...	...	...	...	...	...	...

	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Guns:							
Minor	26	32	42	76	24	31	289
Intermediate	5	5	10	10	12	10	76
Major	3	1	3	4	2	2	28
Projectiles:							
Minor	457,000	604,000	779,000	802,000	589,000	543,000	4,292,000
Intermediate	46,000	82,000	87,000	118,000	112,000	196,000	730,000
Major	1,800	2,200	1,900	4,300	4,300	3,800	23,100
Mounts[1]	...	...	...	...	...	...	664
Smokeless powder......lbs.	369,664	401,202	1,830,463	784,706	2,198,053	986,844	8,715,406
Torpedoes	34	33	58	69	67	45	697
Depth charges	...	1,000	9,118	97	2,325	2,975	15,515

[1] No deliveries by months; total 664.

ORDNANCE CONTRACTS, PRINCIPAL ITEMS, 1918.

	Jan.	Feb.	Mar.	Apr.	May.	June.
Guns:						
Minor	400	...	...	...	300	...
Intermediate	...	150	...	...	100	...
Major	...	...	24	24	...	...
Projectiles:						
Minor	...	100,000	...	...	...	40,000
Intermediate	30,000	...	...	50,000	5,500	500
Major	3,500	...	...	100	24,000	...
Mounts	...	...	250	...	550	...
Smokeless powder......lbs.	...	500,000	...	600,000	...	...
Torpedoes	2,308	120	...	...	...	...
Depth charges	...	...	5,000	15,000	...	...
Mines	...	...	...	...	25,000	...

ORDNANCE CONTRACTS, PRINCIPAL ITEMS 1918.—Continued.

	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Guns:							
Minor							700
Intermediate			1,000	12			1,262
Major							48
Projectiles:							
Minor	1,500,000	22,860	150,000	350,000			2,162,860
Intermediate	97,400	21,000	46,000	100,000	2,000		352,400
Major	40,900	5,000	2,400		15,700		91,600
Mounts	2,261		159			98	3,318
Smokeless powder......lbs		500,000	200,000				1,800,000
Torpedoes	6						2,434
Depth charges	30,000	1,500	500				52,000
Mines				25,000			50,000

ORDNANCE DELIVERIES, PRINCIPAL ITEMS, 1918.

	Jan.	Feb.	Mar.	Apr.	May.	June.
Guns:						
Minor	50	54	45	76	130	176
Intermediate	17	34	34	44	40	66
Major	4	4	5	3	5	3
Projectiles:						
Minor	254,000	254,000	173,000	280,000	327,000	313,000
Intermediate	117,000	174,000	184,000	151,000	183,000	178,000
Major	5,400	4,900	5,800	3,600	3,700	4,800
Mounts	25	30	64	95	140	266
Smokeless powder........lbs	1,885,845	1,541,412	2,448,553	2,839,760	4,311,303	1,613,337
Torpedoes	22	87	118	51	83	123
Depth charges	3,100	1,385		5	150	1,736
Mines		25	23	5,442	15,161	17,837

	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Guns:							
Minor	198	199	213	183	178	120	1,622
Intermediate	100	114	136	186	195	94	1,060
Major	3	3	2	3	2	2	39
Projectiles:							
Minor	340,000	603,000	511,000	530,000	350,000	272,000	4,207,000
Intermediate	177,000	195,000	157,000	152,000	172,000	128,000	1,968,000
Major	4,300	3,600	3,500	2,900	3,000	4,900	50,400
Mounts	386	422	449	656	461	494	3,488
Smokeless powder......lbs	5,528,973	5,801,298	9,703,133	7,544,061	3,633,395	6,029,134	52,880,204
Torpedoes	140	163	129	177	192	210	1,495
Depth charges	3,089	5,126	10,899	7,250	8,168	7,868	48,776
Mines	27,930	11,997	21,576	1,020	1,479	4,374	106,864

ORDNANCE CONTRACTS, PRINCIPAL ITEMS, 1919.

	Jan.	Feb.	Mar.	Apr.	May.	June.	Total.
Torpedoes	1,248		10	722			1,980

ORDNANCE DELIVERIES, PRINCIPAL ITEMS, 1919.

	Jan.	Feb.	Mar.	Apr.	May.	June.	Total.
Guns:							
Minor	101	137	174	213	282	153	1,060
Intermediate	152	204	144	125	182	160	967
Major		1	2				3
Projectiles:							
Minor	309,000	487,000	68,000	154,000	42,000	21,000	1,081,000
Intermediate	138,000	119,000	105,000	64,000	59,000	55,000	540,000
Major	4,400	5,400	7,500	5,500	8,000	8,200	39,000
Mounts	375	363	388	291	345	137	1,899
Smokeless powder......lbs	3,741,869	3,768,584	2,411,145	2,808,176	1,801,522	1,983,184	16,514,480
Torpedoes	58	70	84	389	228	218	1,047
Depth charges	2,596	1,956	2,412	2,000	800	945	10,709
Mines	6,100	5,150	2,400	2,714	992	765	18,121

APPENDIX VIII.

MISCELLANEOUS DATA.

Vessels building, authorized, and in commission Jan. 1, 1917.

Type.	Building.	Authorized.	In commission.
Battleships	8	8	34
Battle cruisers	....	6	0
Scout cruisers and cruisers	1	9	29
Destroyers	29	30	66
Submarines	30	38	40
Gunboats	1	1	21
Auxiliaries	3	8	39
Mine sweepers and tugs	2	....	14
Patrol vessels and yachts	0	0	13
Torpedo boats	0	0	14
Transports	....	....	2
N. O. T. S	0	0	0
Coast Guard	0	0	0
Miscellaneous	0	0	9
Total	74	100	281

Vessels building, authorized, and in commission Nov. 11, 1918.

Type.	Building.	Authorized.	In commission.
Battleships	11	2	39
Battle cruisers	6	....	0
Scout cruisers and cruisers	7	3	31
Destroyers	235	12	107
Submarines	95	10	79
Gunboats	2	....	27
Navy auxiliaries	6	5	32
Eagle class	110	....	1
Subchasers	42	....	299
Mine sweepers and tugs	102	....	123
Patrol vessels and yachts	0	0	291
Torpedo boats	0	0	16
Transports	0	0	41
N. O. T. S	0	0	341
Coast Guard	0	0	33
Miscellaneous	0	0	38
Total	616	32	1,498

Vessels building, authorized, and in commission July 1, 1919.

Type.	Building.	Authorized.	In commission.
Battleships	10	2	36
Battle cruisers	6	....	....
Scout cruisers and cruisers	10	....	28
Destroyers	165	12	167
Submarines	67	10	91
Gunboats	2	....	19
Eagle class	45	....	12
Subchasers	....	....	310
Mine sweepers and tugs	53	....	146
Patrol vessels and yachts	0	0	54
Torpedo boats	0	0	0
Transports	0	0	115
N. O. T. S	0	0	100
Coast Guard	0	0	25
Total	365	28	1,165

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